NETWORK ASSESSMENT FOR THE NATIONAL PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS (PAMS) PROGRAM

DRAFT FINAL REPORT
STI-905410.06-3438-DFR

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Prepared for:
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC

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TABLE OF CONTENTS

Section **Page**

ACKNOWLEDGMENTS iii
LIST OF FIGURES vii
LIST OF TABLES ix

EXECUTIVE SUMMARY 1
ES.1 BACKGROUND 1
ES.2 METHODS 2
ES.3 FINDINGS .... **ERROR! BOOKMARK NOT DEFINED.**
ES.4 SUMMARY OF RECOMMENDATIONS 2

1. INTRODUCTION 1-1
1.1 Background 1-1
1.2 Overview of the PAMS Program 1-1
1.2.1 Data Collected 1-1
1.2.2 Site Types and Monitoring Objectives 1-2
1.2.3 Recent PAMS Regulatory Changes 1-4
1.2.4 Current Sites, Locations, and Data Availability 1-5
1.3 PAMS Network Assessment Study Objectives 1-5
1.4 Guide to this Report 1-6

2. TECHNICAL APPROACH SUMMARY 2-1
2.1 Discussion of Overall Analysis Approach 2-1
2.1.1 Overview of Monitoring Objectives 2-1
2.1.2 Analysis Methods and Biases 2-3
2.1.3 Assessment of PAMS Monitoring Objectives 2-3
2.2 Discussion of Synthesis of Results 2-3

3. NATIONAL LEVEL FINDINGS AND RECOMMENDATIONS 3-1
3.1 Overview 3-1
3.1.1 NAAQS Attainment 3-1
3.1.2 SIP Development and Control Strategy Evaluation 3-3
3.1.3 Emissions Tracking 3-7
3.1.4 Ambient Trend Appraisals 3-8
3.1.5 Exposure Assessment 3-9
3.1.6 EPA OAQPS Discussion Regarding National Findings**Error! Bookmark not defined.**
3.2 Findings by Site Type 3-11
3.2.1 Type 1 – Upwind Sites 3-11
3.2.2 Type 2 – Maximum Precursor Emission Sites 3-12
3.2.3 Type 3 – Maximum Ozone Concentration Sites 3-13
3.2.4 Type 4 – Far Downwind Sites 3-15
3.3 National Network Recommendations 3-15

4. REGION-SPECIFIC FINDINGS AND RECOMMENDATIONS 4-1
4.1 Region 1 – New England 4-1
4.1.1 Overview 4-1
4.1.2 Region 1 Key Findings 4-1
4.1.3 Summary of Region 1 Stakeholder Discussion 4-7
4.1.4 Regional Recommendations 4-7
4.2 Region 2 – Northeast 4-8
4.2.1 Overview 4-8
4.2.2 Region 2 Key Findings 4-8
4.2.3 Summary of Region 2 Stakeholder Discussion 4-10
4.2.4 Regional Recommendations 4-10
4.3 Region 3 – Mid-Atlantic 4-10
4.3.1 Overview 4-10
4.3.2 Region 3 Key Findings 4-10
4.3.3 Summary of Region 3 Stakeholder Discussion 4-16
4.3.4 Regional Recommendations 4-16
4.4 Region 4 – Southeast 4-16
4.4.1 Overview 4-16
4.4.2 Key Findings 4-17
4.4.3 Summary of Region 4 Stakeholder Discussion 4-22
4.4.4 Regional Recommendations 4-22
4.5 Region 5 – Great Lakes 4-22
4.5.1 Overview 4-22
4.5.2 Key Findings 4-22
4.5.3 Summary of Region 5 Stakeholder Discussion 4-27
4.5.4 Regional Recommendations 4-30
4.6 Region 6 – Southern Midwest 4-30
4.6.1 Overview 4-30
4.6.2 Key Findings 4-31
4.6.3 Summary of Region 6 Stakeholder Discussion 4-38
4.6.4 Regional Recommendations 4-38
4.7 Region 9 – Pacific Southwest 4-39
4.7.1 Overview 4-39
4.7.2 Key Findings 4-39
4.7.3 Summary of Region 9 Stakeholder Discussion 4-49
4.7.4 Regional Recommendations 4-49

5. SUMMARY OF RECOMMENDATIONS 5-1
5.1 National Recommendations 5-1
5.2 Regional Recommendations 5-2

6. REFERENCES 6-1

APPENDIX A: DISCUSSION OF ANALYSIS METHODS A-1
APPENDIX B: EXPANDED PAMS ACTIVITIES B-1
APPENDIX C: FINDINGS FROM PREVIOUS STUDIES C-1
APPENDIX D: ADDITIONAL FEEDBACK FROM THE REGIONS D-1

LIST OF FIGURES

Figure **Page**

1-1. PAMS network design as described by the EPA 1-3

1-2. Summary of the PAMS site types and the degree to which each site addresses specific monitoring objectives 1-4

1-3. PAMS sites as of 2006 by EPA region 1-5

3-1. Density of the PAMS network 3-6

3-2. Average MDL at PAMS monitors for n-octane from 2004-2006........ 3-7

3-3. Benzene concentrations for 6-9 a.m. 2004-2006 at all PAMS sites 3-10

3-4. Afternoon acetaldehyde concentrations for 12-3 p.m. 2004-2006 at all PAMS sites.... 3-10

4-1. Average number of days per year with ozone concentrations greater than 75 ppb from 2004-2006 in Region 1 and parts of Region 2 4-2

4-2. Average number of days a site has maximum ozone concentrations greater than 75 ppb in nonattainment areas in Region 1 and parts of Region 2 4-3

4-3. Morning ethylbenzene concentrations at northeastern PAMS sites 4-4

4-4. Emissions density of NO_x in Region 1 in 2002 4-5

4-5. Emissions density of VOCs in Region 1 for 2002 4-6

4-6. Morning n-octane concentrations in the Northeast at PAMS sites. 4-9

4-7. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Region 3 4-11

4-8. Average number of days a site experienced maximum ozone concentrations greater than 75 ppb in nonattainment areas in Region 3 4-12

4-9. Morning sum of PAMS target compound concentrations in the Northeast corridor at PAMS sites........ 4-13

4-10. Emissions density of NO_x in Region 3 for 2002........ 4-14

4-11. Emissions density of VOCs in Region 3 for 2002 4-15

4-12. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Atlanta........ 4-18

4-13. Average number of days a site experiences maximum ozone concentrations greater than 75 ppb in nonattainment areas in Atlanta 4-19

4-14. Emissions density of NO_x in Atlanta for 2002 4-20

4-15. Emissions density of VOCs in Atlanta for 2002 4-21

4-16. Average number of days per year when ozone oncentrations were greater than 75 ppb from 2004-2006 in the Lake Michigan area 4-23

4-17. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Lake Michigan area 4-24

4-18. Emissions density of NO_x in Lake Michigan for 2002 4-25

4-19. Emissions density of VOCs in Atlanta for 2002 4-26

4-20. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in the East Texas area 4-32

4-21. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Baton Rouge 4-33

4-22. Average number of days at a site when maximum ozone concentrations were greater than 75 ppb in nonattainment areas of East Texas and Louisiana 4-34

4-23. Emissions density of NO_x in Baton Rouge for 2002 4-35

4-24. Emissions density of VOCs in Baton Rouge for 2002 4-36

4-25. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Central California 4-39

4-26. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Southern California 4-40

4-27. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Central California 4-41

4-28. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Southern California 4-42

4-29. Emissions density of NO_x in Central California in 2002 4-43

4-30. Emissions density of VOCs in Central California in 2002 4-44

4-31. Emissions density of NO_x in Southern California in 2002 4-45

4-32. Emissions density of VOCs in Southern California in 2002 4-46

LIST OF TABLES

Table **Page**

2-1. Analysis matrix detailing the analyses performed and the monitoring objectives addressed ... 2-2

3-1. Nonattainment status classifications for 2005-2007 from the EPA Greenbook ... 3-2

3-2. Highest average 4th maximum ozone for the 2004-2006 and 2005-2007 time periods and relative ozone concentrations for nonattainment areas ... 3-2

3-3. Ranking of PAMS areas for which the number of 8-hr maximum ozone concentrations exceeds 75 ppb for 2004 through 2006 ... 3-3

3-4. Concentrations of key PAMS precursor pollutants and ranking of concentrations across PAMS areas ... 3-4

3-5. Highest-density Type 2 sites by PAMS nonattainment area ... 3-5

3-6. Areas where large numbers of parameters are monitored at multiple sites ... 3-9

4-1. Region 1 site-specific observations ... 4-7

4-2. Region 2 site-specific observations ... 4-9

4-3. Region 3 site-specific observations ... 4-16

4-4. Site-specific observations for Region 4 ... 4-21

4-5. Region 5 site-specific observations ... 4-27

4-6. Region 6 site-specific observations ... 4-36

4-7. Region 9 site-specific observations ... 4-47

EXECUTIVE SUMMARY

ES.1 BACKGROUND

The Photochemical Assessment Monitoring Stations (PAMS) program collects ambient air measurements in areas classified as serious, severe, or extreme ozone nonattainment, as required by Section 182(c)(1) of the Clean Air Act. PAMS are used to collect data for a target list of volatile organic compounds (VOCs), nitrogen oxides (NOx, NOy), ozone, and surface and upper-air meteorological measurements. In 2006, the U.S. Environmental Protection Agency (EPA) reduced minimum PAMS monitoring requirements to establish a network that meets the national objectives of the program while freeing up resources for states to tailor their networks to suit specific data needs. Overall, the changes significantly reduce the costs of the minimum PAMS monitoring requirements and allow states to re-invest these savings in region-specific PAMS monitoring activities.

The PAMS Network Assessment project was a collaboration of federal, regional, and state PAMS participants with the objectives of assessing how well the current PAMS network is meeting its monitoring objectives; determining which sites are most useful for meeting these objectives; identifying potentially redundant, ineffective, or unnecessary sites; and assessing other enhanced ozone monitoring activities that may prove useful.

The PAMS network was established in the mid-1990s in ozone nonattainment areas to provide information on the effectiveness of control strategies, emissions tracking, trends, and exposure. State and local air pollution control agencies operate the PAMS sites. A PAMS monitoring site typically monitors 56 target hydrocarbons and 2 carbonyl compounds, ozone, NO_x and/or NO_y, and meteorological measurements. The conceptual PAMS network design was developed to include measurements collected at defined locations within an urban region to meet specific objectives based on a site's location relative to emissions and transport pathways in a given area. The site types and objectives are defined as follows:

- Type 1 - Upwind and background characterization site
- Type 2 - Maximum ozone precursor emissions impact sites
- Type 3 - Maximum ozone concentration sites
- Type 4 - Extreme downwind monitoring sites

The PAMS network consists of 78 sites in 23 areas that have been classified as serious ozone nonattainment areas. Because many of the existing PAMS sites were established in the mid- to late 1990s, site characteristics may have changed since installation. For example, as city boundaries have expanded, sites that were originally upwind of emissions sources may now be impacted by fresh emissions. In addition, Type 3 sites were originally installed to address peak 1-hr ozone concentrations; however, regulatory emphasis is now on peak 8-hr concentrations. Moreover, control measures have resulted in a less reactive hydrocarbon precursor mixture, which may shift the location(s) and occurrence of peak ozone concentrations.

ES.2 OVERVIEW OF ANALYSIS METHODS

The PAMS monitoring network was established to obtain data useful for meeting the following set of monitoring objectives: NAAQS attainment and control strategy development, state implementation plan (SIP) control strategy evaluation, emissions tracking, ambient trend appraisals, and exposure assessment. These monitoring objectives are discussed in detail on the EPA PAMS web sites (http://www.epa.gov/ttn/amtic/pamsmain.html and http://www.epa.gov/oar/oaqps/pams/). One of the main purposes of this study was to identify how well the PAMS network is meeting these established objectives. To achieve this, a series of analyses were identified to address each of the objectives listed above. In the initial stages of this study, Sonoma Technology, Inc. (STI) worked with the PAMS Network Assessment Work Group (WG) to compile an analysis matrix that identified the monitoring objectives that individual analyses would address. The WG then prioritized the analyses to perform.

Because compliance with the National Ambient Air Quality Standard (NAAQS) is the driving force behind the PAMS monitoring program, NAAQS attainment analyses were performed. In addition, analysis efforts were focused on identifying areas within PAMS networks where ozone concentrations are highest and comparing these areas to the actual locations of PAMS Type 3 sites (maximum ozone concentration sites).

An important aspect of synthesizing the results of the network assessment analyses is to consider the results holistically and to understand that no one analysis stands alone. To synthesize the results, individual analyses were ranked in terms of their importance in addressing a monitoring objective. For example, in this study, a high priority was to understand how well Type 3 PAMS sites meet their objective of measuring maximum ozone concentrations; therefore, the Maximum Ozone Location analysis was assigned a high importance rating when the results were viewed together. In contrast, the Number of Samples Measured analysis was not as important and was assigned a lower rating. The analyses performed in this network assessment were rated as very high, high, medium, and low according to their importance. Particular attention was paid to Type 2 and 3 sites, which provide the most value in terms of meeting the monitoring objectives because they are specifically sited to capture maximum ozone precursor emissions (Type 2) and maximum ozone concentrations (Type 3). Recommendations for future analyses that could be performed to expand on this work were made.

ES.3 SUMMARY OF FINDINGS AND RECOMMENDATIONS

National Recommendations

Monitoring efforts and resources should be greatest in areas where ozone concentrations are highest and minimized in areas where ozone concentrations are relatively low. California and Texas have the most severe ozone problems in the country. Current PAMS monitoring in the Sacramento and San Joaquin Valley areas of California appears inadequate. Monitoring resources appear to be adequate in southern California; however, it appears that some monitors should be moved farther downwind into Riverside and San Bernardino to better capture maximum ozone concentrations. In Texas, the number of monitors in Houston and Dallas appears to be adequate, although some monitors may need to be relocated to better capture maximum ozone concentrations.

The mid-Atlantic to Northeast monitoring networks are dense and contain a disproportionate number of monitors given the magnitude of the ozone problems in these areas. However, this region is densely populated and may, therefore, warrant a denser monitoring network to address population exposure. Redundancy analyses should be performed in these areas to determine if monitors could be removed without the loss of valuable information.

Note that only existing PAMS areas were assessed in this work. However, it should be noted that some areas currently not designated as PAMS areas experience higher ozone concentrations or larger numbers of exceedances than some areas that are currently designated as PAMS. A reassessment of the serious ozone areas under the new ozone standard would be a useful national analysis.

To improve data quality in key PAMS areas, EPA should consider lowering the required or minimally allowable MDL. While all areas may be meeting minimum requirements for VOC measurements and reporting, these minima are inadequate, resulting in a large amount of data reported below the MDL. National-scale requirements for MDL values should be strengthened to reflect the lower precursor concentrations routinely observed.

Reassess and relocate most maximum ozone concentration monitoring site locations. Analyses indicated that many Type 3 maximum ozone concentration sites are not located at or near the actual areas of highest ozone concentrations in nonattainment areas. During the 10 to 15 years that the PAMS program has been in existence, shifts in population, urban development, emissions, VOC reactivity, and the ozone standard have all changed. While the location of maximum precursor emission sites are still generally in areas of high emissions, multiple analyses indicated that maximum ozone concentration sites are often located too close to the urban core. Given the design of the monitoring network, current Type 3 sites can be repurposed as Type 2 sites or should be relocated to capture the maximum ozone concentrations.

EPA should consider improving accountability of the PAMS program dollars, including regular reporting of data quality and use. In addition, updating the EPA web site with local and regional PAMS reports would be useful for information-sharing. Most of the information available on the web site is out of date. There are no internal quality assurance programs run by the EPA that assess the quality of data being produced by PAMS monitors. EPA should consider providing additional support and organization for the data being collected under the PAMS program.

Regional Recommendations

Regional recommendations were developed based on the results of the network assessment analyses and from input from local PAMS program operators. Recommendations were developed for both individual monitoring sites and for each of the regional networks. In summary, it is recommended that each region perform a more localized, regional network assessment to target local needs and unique regional issues. This local assessment should include more sophisticated analyses (e.g., source apportionment, correlation analyses, or simple scatter plot matrices) to identify redundant monitors.

1. INTRODUCTION

1.1 BACKGROUND

Photochemical Assessment Monitoring Stations (PAMS) collect ambient air measurements in areas classified as serious, severe, or extreme ozone nonattainment as required by Section 182(c)(1) of the Clean Air Act (CAA). PAMS are used to collect data for a target list of volatile organic compounds (VOCs), nitrogen oxides (NO_x), reactive oxides of nitrogen (NO_y), ozone, and surface and upper-air meteorological measurements. The PAMS network was established in the mid-1990s across the United States to provide information about the effectiveness of control strategies, emissions tracking, trends, and exposure. As the program has matured, monitoring methods and objectives have changed, equipment has aged, and pollutant concentrations and regulatory requirements have changed. As a result, it is important to consider how best to balance or redirect resources to meet the evolving PAMS program objectives.

Since its inception, the PAMS program has been in operation without substantial modification or adjustment in the context of the initial program objectives established in the early 1990s. This project presents an opportunity to assess the current PAMS monitoring network in light of changes in the ozone standard and recently promulgated changes in PAMS requirements. The objective of this project is to evaluate the current state of the PAMS network on a national level and to provide insights to understand how well the current network is meeting historic and current PAMS monitoring objectives. As part of this work, the efficiency of the national network was assessed and analyses were performed to help decision-makers and stakeholders determine how to most effectively distribute PAMS program funds.

An enormous effort, both in cost and labor, has been made over the years to establish, operate, and maintain the PAMS network. An attempt is made in this project to provide an objective review of the network. The findings and recommendations contained in this report are intended to guide the improvement of the overall network, given the limited resources available. Additional analyses are needed to assess redundancy among sites and to determine appropriate locations to place new monitors and/or reallocate existing resources.

1.2 OVERVIEW OF THE PAMS PROGRAM

The PAMS network was established in the mid-1990s in ozone nonattainment areas to gather information about the effectiveness of control strategies, emissions tracking, trends, and exposure. This section describes the data collected, site types and monitoring objectives, recent PAMS regulatory changes, and current sites, locations, and data availability.

1.2.1 Data Collected

State and local air pollution control agencies operate the PAMS sites. A PAMS monitoring site typically monitors 56 target hydrocarbons and 2 carbonyl compounds, ozone, NO_x and/or NO_y, and meteorological parameters. Sample speciation may vary among sites as some agencies report more hydrocarbons and/or carbonyl compounds than the PAMS target list.

Differences among analytical techniques can also alter the list of chemical species collected (e.g., co-eluters).

Sampling frequency varies among regions, states, and sites in the PAMS program. For example, hydrocarbons have historically been sampled on a 1-hr or 3-hr average basis; may or may not cover a 24-hr period; and are collected every day or every third day or episodically. Carbonyl compounds are typically collected as 3-hr averages every third day but other sampling variations exist. Most sites make surface meteorological measurements, including wind speed, wind direction, and temperature reported hourly. Upper-air meteorological measurement requirements may be met in a number of ways, including using rawinsondes, radar wind profilers RWPs), or twice-daily National Weather Service (NWS) soundings.

1.2.2 Site Types and Monitoring Objectives

The conceptual PAMS network design, shown in **Figure 1-1**, was developed to include data collected at different locations within an urban region and as such, four site types with different measurement objectives were established (U.S. Environmental Protection Agency, 2008a). The site type objectives are based on a site's location relative to the emissions and transport pathways in an area and are defined as follows:

- **Type 1 – Upwind and background characterization site**. Type 1 sites are intended to characterize upwind background and transported ozone and its precursor concentrations entering the area. Type 1 sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions and at a distance sufficient to obtain urban scale measurements.
- **Type 2 – Maximum ozone precursor emissions impact sites**. Type 2 sites are intended to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions representative of the metropolitan statistical area (MSA, or consolidated MSA) are expected to impact. Type 2 sites are located immediately downwind of the area of maximum precursor emissions. They are typically placed near the downwind boundary of the central business district (CBD) or primary area of precursor emissions mix to obtain neighborhood-scale measurements. These sites are also referred to as urban or urban center sites. If additional Type 2 monitoring is required, the Type 2A sites are placed in the second-most predominant morning wind direction.
- **Type 3 – Maximum ozone concentration sites**. Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions. Typically, these sites are located 10 to 30 miles from the fringe of the urban area.
- **Type 4 – Extreme downwind monitoring sites**. Type 4 sites are intended to characterize the extreme downwind transported ozone and its precursor concentrations exiting the area. Type 4 sites are located in the predominant afternoon downwind direction from the local area of maximum precursor emissions at a distance sufficient to obtain urban-scale measurements.

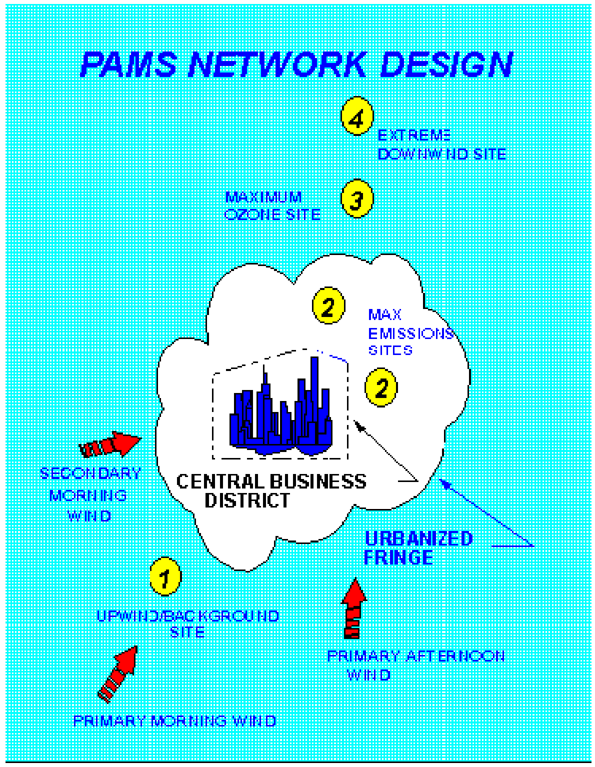

Figure 1-1. PAMS network design as described by the EPA (U.S. Environmental Protection Agency, 2008a). PAMS site Types 1 through 4 are shown here.

It is convenient to use the site types defined by the EPA to discuss the PAMS data in this report because the PAMS monitoring and analysis community is familiar with these designations. While site types may be clearly defined from a political boundary perspective, they may be less clearly defined in a region as a whole. For example, a Type 4 site may also be a Type 1 site for another PAMS area. These sites are often designated as Type 1/4 or similar nomenclature.

Sites were originally located based on specified siting criteria. Because many of the PAMS sites were established in the mid- to late 1990s, site characteristics may have changed since installation. For example, as city boundaries have expanded sites that were originally upwind of emissions sources may now be impacted by fresh emissions. In addition, Type 3 sites were originally installed to address peak 1-hr ozone concentrations; however, the regulatory emphasis is now on peak 8-hr concentrations. Moreover, control measures have resulted in a less reactive hydrocarbon precursor mixture which may shift the location(s) and occurrence of peak ozone concentrations.

The number of PAMS sites varies among MSAs. Ozone precursors (VOCs and NO_x) and surface meteorology were originally required to be measured at two to five sites in an MSA, depending on the MSA population. In addition, upper-air meteorological measurements were required at one representative site in an MSA.

When properly located, each monitoring site type is intended to meet specific objectives. A summary of the monitoring objectives by site type is shown in **Figure 1-2**. Note that site Types 2 and 3 provide the most value in terms of the number of monitoring objectives they cover.

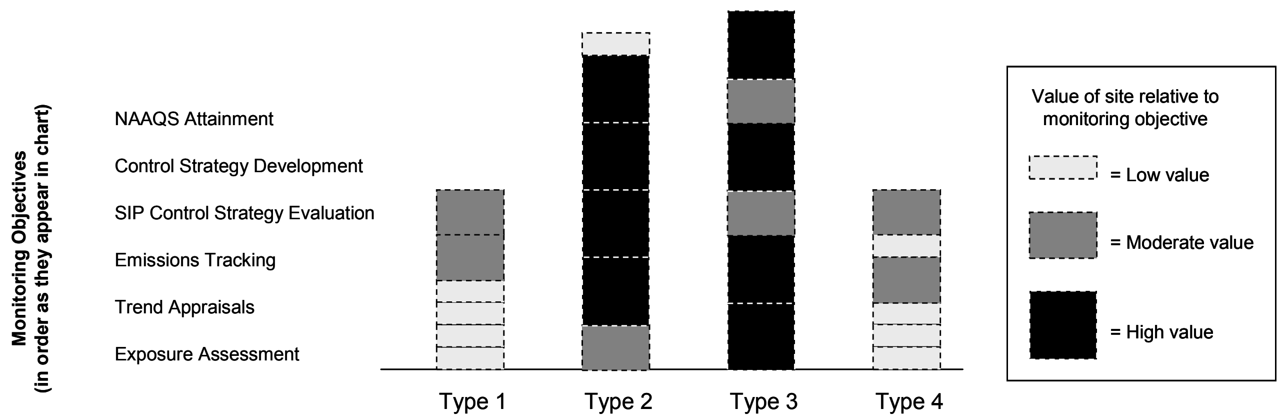

Figure 1-2. Summary of the PAMS site types and the degree to which each site addresses specific monitoring objectives.

1.2.3 Recent PAMS Regulatory Changes

The U.S. Environmental Protection Agency (EPA) finalized revisions to the current PAMS monitoring requirements on October 17, 2006. The revisions greatly reduce the minimum PAMS requirements. The intent of the revisions is to establish the minimum PAMS network necessary to meet the national objectives of the PAMS program while freeing up resources for states to tailor PAMS networks to suit their specific data needs. Overall, the changes significantly reduce the costs of the minimum PAMS monitoring requirements and allow states to re-invest these savings in area-specific PAMS monitoring activities.

Several changes specific to PAMS have been made as a result of the new monitoring rule:

- *Reduced number of required PAMS sites*. Only one Type 2 site is required per area, regardless of population, and Type 4 sites are not required. Only one Type 1 or one Type 3 site is required per area.
- *Reduced requirements for speciated VOC measurements*. Speciated VOC measurements are only required at Type 2 sites and one other site (either Type 1 or Type 3) per PAMS area.
- *Reduced carbon compound sampling*. Carbonyl compound sampling is required only in areas classified as serious or above for the 8-hr ozone standard.
- *Changed nitrogen monitoring*. NO_2/NO_x monitors are required only at Type 2 sites while NO_y monitoring is required at one site per PAMS area (either Type 1 or Type 3).
- *Additional CO monitoring*. Trace level CO monitoring is required at Type 2 sites.

As part of an overall review of State and Tribal Air Grants (STAG) utilization and allocations, EPA is working with the states to evaluate the PAMS network in an effort to determine if funding should (1) remain at $14 million per year and (2) be shifted among states in fiscal year 2008 to ensure that the available funds are used to conduct the most essential monitoring in the most appropriate locations.

1.2.4 Current Sites, Locations, and Data Availability

The PAMS network consists of 78 sites in 23 areas (circa 2006) that were classified as serious ozone nonattainment areas (**Figure 1-3**). A complete list of available data by site can be found on the PAMS Network Assessment website, <http://www.epa.gov/ttn/amtic/pams_assessment/>.[1]

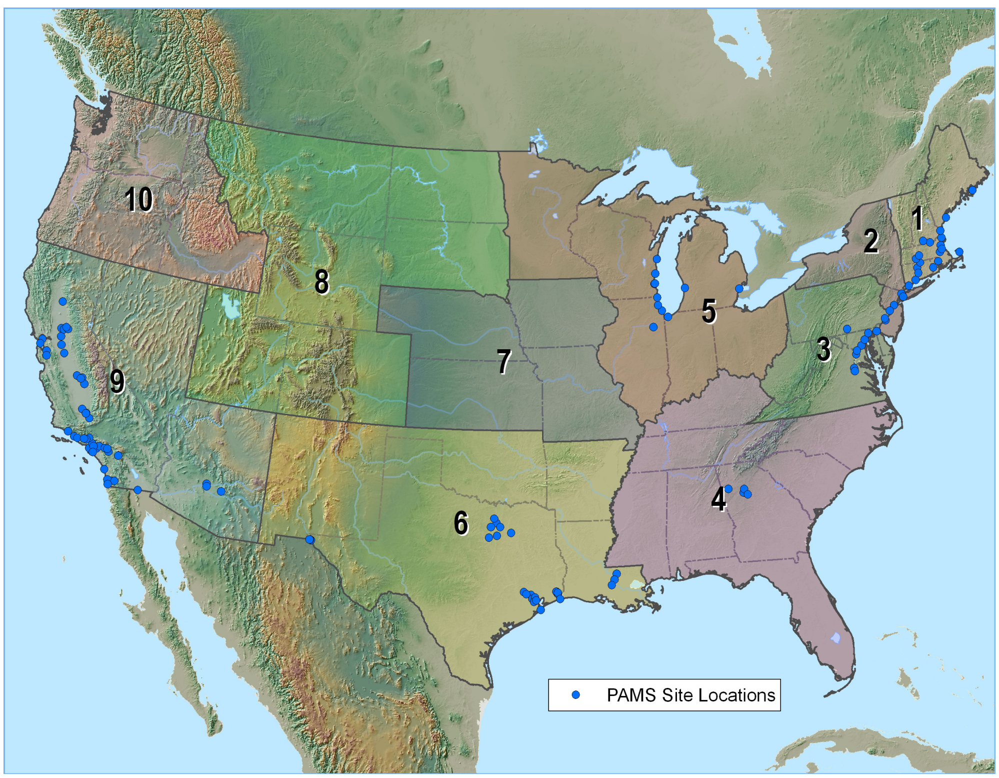

Figure 1-3. PAMS sites as of 2006 by EPA region.

1.3 PAMS NETWORK ASSESSMENT STUDY OBJECTIVES

The objectives of the PAMS network assessment are to (1) assess how well the current network is meeting its monitoring objectives, (2) determine which sites are most useful for meeting these objectives, (3) identify any redundant, ineffective, or unnecessary sites, (4) recommend any changes in methods, equipment, or automation that can make existing

[1] This website is password-protected. Please contact Kevin Cavender, cavender.kevin@epa.gov.

monitoring sites more efficient, and (5) assess other expanded ozone monitoring activities that may prove useful. Given the limited resources available for this study and the broad project scope, not all objectives could be thoroughly covered. However, recommendations for future national-scale analyses and region-specific analyses have been provided. The intention is that regional PAMS program managers will use the information in this report to further assess regional PAMS networks to better assess regional program needs and resource allocation.

This project and process was conducted as a team effort with participation from the states and EPA regions. Monthly progress meetings were conducted to discuss findings and obtain stakeholder feedback. Notes from these meetings were distributed. Draft and final analysis results were provided on a website for review by the team. Stakeholder feedback was solicited throughout the process and feedback was solicited regarding the results and recommendations contained in this report. Stakeholder feedback regarding the regional results and recommendations is included in this document.

The analysis methods employed IN this study were chosen to address the following questions:

1. Is the PAMS network helping to determine ozone National Ambient Air Quality Standards (NAAQS) attainment?
2. Is the PAMS network helping to better characterize the nature and extent of the ozone problem and aiding in state implementation plan (SIP) development?
3. Does the PAMS network facilitate tracking VOC and NO_x emission inventory reductions?
4. Is the PAMS network adequate for assessing exposure?
5. Is the PAMS network operating at an acceptable level of efficiency? Is the network cost-effective?
6. Is the PAMS network meeting data quality objectives (DQOs)?
7. Are the initial objectives still viable given the change in the ozone standard?

1.4 GUIDE TO THIS REPORT

Section 2 summarizes the technical approach employed to analyze and understand the overall network in terms of its ability to meet monitoring objectives and to formulate recommendations for improvements to the network. Section 3 includes a summary of the study findings and results for the national PAMS network while Section 4 is a summary of findings specific to the regional networks. Section 5 offers conclusions and recommendations to improve the national PAMS monitoring network. Section 6 lists all the references cited in this document. Appendix A provides additional details about the analysis methods. Appendix B is a discussion of surveys and stakeholder feedback regarding expanded PAMS activities. Appendix C lists findings from previous PAMS network studies. Appendix D contains supplemental stakeholder feedback and information.

2. TECHNICAL APPROACH SUMMARY

Sonoma Technology, Inc. (STI) worked with the PAMS Network Assessment Workgroup (WG)[2] to select a series of prioritized analyses to evaluate the PAMS network. Only the highest priority analyses, as ranked by the WG, were performed. This section summarizes the approach taken. Detailed approach methodologies and individual network assessment analyses are discussed in Appendix A.

2.1 DISCUSSION OF OVERALL ANALYSIS APPROACH

Given the limited resources available for this study and the broad scope of the project, a selected number of prioritized analyses were performed. High priority analyses addressed some aspects of the network assessment, but may not have been sufficient to thoroughly answer all questions of interest for this network assessment. This section provides an overview of the monitoring objectives that were assessed, and the questions and analyses that were omitted. Omitted objectives and questions are presented here so that they can be included in future network assessments or investigated by individual EPA regions for region-specific analyses.

2.1.1 Overview of Monitoring Objectives

The PAMS monitoring network was established to obtain data useful for meeting the following set of monitoring objectives:

- NAAQS Attainment and Control Strategy Development
- SIP Control Strategy Evaluation
- Emissions Tracking
- Ambient Trend Appraisals
- Exposure Assessment

These monitoring objectives are thoroughly covered on the EPA PAMS websites (U.S. Environmental Protection Agency, 1999, 2008b).

In the initial stages of this study, STI worked with the WG to explore possible analyses to be performed in the network assessment. As part of that exploration, STI compiled an analysis matrix identifying the monitoring objectives that individual analyses would address. The WG prioritized the analyses to be performed. **Table 2-1** shows the final analyses performed and the monitoring objectives they addressed.

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[2] The PAMS Network Assessment Workgroup consists of EPA regional and state and local PAMS representatives who volunteered to participate.

Table 2-1. Analysis matrix detailing the analyses performed and the monitoring objectives addressed.

		Monitoring Objectives				
Analysis Type	**Analyses**	**NAAQS Attainment and Control Strategy Development**	**SIP Control Strategy Evaluation**	**Emissions Tracking**	**Ambient Trend Appraisals**	**Exposure Assessment**
Site-by-Site	Number of other parameters monitored at site			✓		✓
	Trends Impact (length of record)		✓		✓	
	Data quality (MDL)	✓			✓	
	Number of samples			✓	✓	
	Attainment status	✓				
	Measured Concentrations	✓	✓			✓
	Distance matrix	✓				
Bottom-up	Emission inventory			✓		
Network Optimization	Maximum ozone locations	✓	✓			

2.1.2 Analysis Methods and Biases

Overall, the analyses performed were biased toward assessing the available sites and ranking them within the existing network. While this approach is useful for classifying the high value sites among existing monitoring sites, this type of analysis limits the ability to judge the regional or local networks holistically to understand how well they are meeting their monitoring objectives (i.e., network optimization) or to understand whether the existing locations are sited optimally (i.e., bottom-up analyses).

2.1.3 Assessment of PAMS Monitoring Objectives

Table 2-1 detailed the monitoring objectives addressed by each analysis. The NAAQS Attainment and Control Strategy Development and Emissions Tracking objectives were covered most thoroughly. Given the regulatory importance of NAAQS attainment, it is not surprising that this topic is more thoroughly covered. Similarly, the Emissions Tracking objective is paramount to understanding and quantifying the sources from which precursors originate and controlling them to reduce ozone concentrations.

2.2 DISCUSSION OF SYNTHESIS OF RESULTS

In discussion with Kevin Cavender and before discussion with the WG, the various analyses were rated in order of importance:

- Very high – Attainment status, maximum ozone location
- High – Measured concentrations
- Medium – Distance matrix (monitoring density)
- Low – Number of parameters, percent below MDL, number of samples measured, length of trend record, and emission inventory

Findings are organized by monitoring objective. Analyses that apply to a given monitoring objective are included and relevant findings are discussed.

3. NATIONAL LEVEL FINDINGS AND RECOMMENDATIONS

3.1 OVERVIEW

This section provides results and recommendations from the analyses organized by monitoring objective and site type at the national level. Select results illustrating the findings are shown, but by necessity, not all figures and/or information are included in this document in order to reduce the overall length of the report. Supplemental material is available on the PAMS Network Assessment website (U.S. Environmental Protection Agency, 2008a).

3.1.1 NAAQS Attainment

NAAQS Attainment is the driving force behind the PAMS monitoring program. The results from the nonattainment analyses have the most influence on the recommendations developed for the national and regional monitoring networks.

Four areas are currently above Moderate Nonattainment Status (see **Table 3-1**): the Los Angeles South Coast Air Basin (SoCAB) is designated as Severe 17, while Riverside, Sacramento, and the San Joaquin Valley (SJV) are all designated as Serious. All other areas are designated Moderate, Marginal, or below. Areas from which PAMS hydrocarbon data are available are included in this list. Note that areas where PAMS measurements are not made, but where frequent elevated ozone concentrations occur, are not included in Table 3-1.

To expand on the information contained in Table 3-1, **Table 3-2** shows attainment classifications using three-year averages of 4th 8-hr maximum calculations.[3] The classifications in this table are generally in good agreement with EPA Greenbook designations (U.S. Environmental Protection Agency, 2008c, 8-hour ozone). The number of ozone exceedances in an area generally follows the concentrations listed in Table 3-2. The average number of days from 2004-2006 when ozone concentrations were greater than 75 ppb at any given site was determined for each of the major nonattainment areas listed. Areas were ranked based on the number of 8-hr maximum ozone concentrations greater 75 ppb and the results are shown in **Table 3-3**.

Findings:

- The highest number of 8-hr maximum ozone concentrations greater than 75 ppb occurs in California, followed by Texas.
- The lowest number of 8-hr maximum ozone concentrations greater than 75 ppb occurs in the Northeast and Lake Michigan areas.

[3] Note these are not official design values since the 2007 data were not finalized when the calculations were made and exceptional events were not removed.

Table 3-1. Nonattainment status classifications for 2005-2007 from the EPA Greenbook (U.S. Environmental Protection Agency, 2008c, 8-hour ozone).

Severe 17 (*) or Serious	Moderate	Marginal	Subpart 1 or Other
Los Angeles, CA*	Baltimore, MD	Atlanta, GA	San Diego, CA
Riverside, CA	Boston, MA	Baton Rouge, LA	Phoenix, AZ
Sacramento, CA	Houston, TX	Beaumont, TX	
San Joaquin Valley, CA	Dallas-Fort Worth, TX		
	Chicago, IL		
	Milwaukee, WI		
	Springfield, MA		
	Greater Connecticut		
	New York, NY		
	Philadelphia, PA		
	Washington DC		
	Ventura Co., CA		
	Providence, RI		

Table 3-2. Highest average 4th maximum ozone for the 2004-2006 and 2005-2007 time periods and relative ozone concentrations for nonattainment areas. PAMS sites only (not to be used for attainment consideration).

Page 1 of 2

AQS Site Code	Current Nonattainment Area	2004-2006 ozone 4th max 8-hr avg (ppb)	2005-2007 ozone 4th max 8-hr avg (ppb)
060712002	Los Angeles South Coast Air Basin	113.2	113.7
060295001	San Joaquin Valley	110.7	107.1
060670012	Sacramento Metro	96.2	97.1
481210034	Dallas-Fort Worth	95.5	94.5
482011039	Houston-Galveston-Brazoria	96.8	93.0
132470001	Atlanta	91.6	95.2
090070007	New York, NY	89.4	92.9
260050003	Allegan Co	88.3	93.3
090131001	Greater Connecticut	89.4	91.3
061112002	Ventura Co	90.5	88.3
240259001	Baltimore	88.0	91.7
340230011	New York, NY	88.3	89.9
250130008	Springfield (Western MA)	86.3	92.9
340210005	Philadelphia	87.4	91.2
510590030	Washington DC-MD-VA	89.2	86.8
060731006	San Diego	87.9	88.8
250213003	Boston (E.MA)	83.6	86.9

Table 3-2. Highest average 4th maximum ozone for the 2004-2006 and 2005-2007 time periods and relative ozone concentrations for nonattainment areas. PAMS sites only (not to be used for attainment consideration).

AQS Site Code	Current Nonattainment Area	2004-2006 Ozone 4th Max 8-hr Avg (ppb)	2005-2007 Ozone 4th Max 8-hr Avg (ppb)
440030002	Providence, RI	83.2	85.9
550710007	Manitowoc Co	82.8	86.3
482450101	Beaumont, TX	86.4	81.8
550890009	Milwaukee-Racine, WI	79.9	83.7
220330013	Baton Rouge, LA	81.4	81.4
040218001	Phoenix-Mesa, AZ	79.3	80.1
180890022	Chicago, IL	75.0	82.4
330115001	Boston-Manchester-Portsmouth(SE)	78.0	80.4
481410037	El Paso, TX	78.5	80.0

Table 3-3. Ranking of PAMS areas for which the number of 8-hr maximum ozone concentrations exceeds 75 ppb for 2004 through 2006.

Rank	PAMS Areas	Number of 8-hr Maximum Ozone Concentrations > 75 ppb
1	San Joaquin Valley, CA	100+
2	Los Angeles and Riverside Counties, CA	90+
3	Sacramento, CA	40+
4	Dallas and Fort Worth, TX	32-34
5	Ventura County, CA	30
6	Houston, TX	25-30
7	Phoenix, AZ	23
8	Washington DC, Baltimore, MD, Philadelphia, PA, San Diego, CA, Atlanta, GA, Beaumont, TX	17-23
9	New York, NY, Baton Rouge, LA	16-18
10	Connecticut, Massachusetts (Eastern and Western), Rhode Island, Lake Michigan area	10-15
11	El Paso, TX	Less than 10

3.1.2 SIP Development and Control Strategy Evaluation

Control strategies are developed using precursor concentration data collected at PAMS sites, particularly at Type 2 sites. Measured concentrations were examined to determine the relative levels of precursor concentrations. Sites in each PAMS nonattainment area measuring the highest concentrations of key precursor pollutants are listed in **Table 3-4**. Similar to area rankings for ozone, the highest ranked areas are the South Coast and San Joaquin Valley areas in

California, followed by the Houston and El Paso areas in Texas. A large number of areas were characterized by relatively consistent rankings of precursor concentrations: Baton Rouge, Louisiana; New York, New York; Connecticut; Ventura County, California; Atlanta, Georgia; San Diego, California; Detroit, Michigan; Beaumont and Dallas, Texas; and the Chicago, Illinois, areas. The remaining area rankings dropped off precipitously, with the upper Northeast areas having the lowest average pollutant precursor rankings at their monitoring sites.

The density of the national monitoring network was examined using two spatial metrics: (1) the distance between all sites and (2) the distance between Type 2 sites. The results of both analyses were very similar; therefore, only the Type 2 site results are shown in **Table 3-5**. Monitoring stations are densely located in Los Angeles, the upper Northeast, and Houston. Low-density monitoring areas include El Paso, Phoenix, Atlanta, Baton Rouge, and the Lake Michigan area. **Figure 3-1** shows a map of the density of the PAMS network.

Table 3-4. Concentrations of key PAMS precursor pollutants and ranking of concentrations across PAMS areas. Concentrations of hydrocarbons are in ppbC, NO_x concentrations are in ppb.

AQS_ Code	PAMS Area	Site Name And Type	Oxides of nitrogen	Benzene	Ethylene	n-Butane	Propylene	Sum of PAMS target compounds	Total NMOC	Average VOC rank	Average NO_x	Total VOC and NO_x rank
060371002	S. Co./SEDAB	Burbank # 1/#2	104	4.3	8.7	13.1	3.5	262	343	7	6	7
060290010	San Joaquin	Bakersfield #2	58	3.7	3.0	12.7	2.6	211	1141	14	13	13
482011035	Houston	Clinton Dr. # 2	45	4.5	8.1	29.1	7.6	239	277	8	34	17
481410044	El Paso	Chamizal # 2	48	4.3	5.6	9.7	2.9	136	155	18	28	21
220330009	Baton Rouge	Capitol # 2	35	4.2	9.4	17.5	5.1		198	10	46	24
360050083	New York	Bronx Bot Gar # 2	56	2.0	3.8	3.6		95	189	29	16	24
090090027	Connecticut	New Haven #2A	53		2.4	10.2	1.1	132	158	29	18	25
061112002	Ventura Co.	Simi Valley #3	40	3.3	5.3	4.8	2.3	140	992	18	41	26
130890002	Atlanta	South DeKalb #2	79	2.5	3.7	4.4	2.2	98	116	29	22	26
060730003	San Diego	El Cajon # 2	47	2.3	5.5	3.2	2.2	108	164	27	28	27
340070003	Philadelphia	Camden # 2A	45	1.9	2.4	6.3	3.4	103	149	28	28	28
261630019	Detroit	E. Seven Mile	34	3.5	3.3	7.6	2.1	132	182	23	47	31
482450009	Beaumont	Lamar #2	18	3.6	7.5	28.5	3.6	219	241	12	72	32
481130069	Dallas	Hinton #2	43	1.4	2.9	9.1	1.9	95	108	32	32	32
180890022	Lake Michigan	Gary-IITRI # 2	43	2.9	3.0	3.3	1.5	145	101	31	34	32
240053001	Baltimore	Essex # 2	44	1.6	2.7	3.3	1.4	78	101	38	34	36
110010043	Washington	McMillan Res #2	47	1.2	1.9	2.4	0.8	54	67	51	25	42
060670006	Sacramento	Del Paso # 2A	31	1.3	2.5	1.9	1.7	64	53	45	55	48
250250041	Boston	Long Island # 2A	16	1.1	2.0	1.5	1.3	34	38	56	76	62
250130008	Springfield	Chicopee # 2	19	0.7	1.6	1.7	0.6	38	43	61	69	64
440071010	Providence	E. Prov. # 2	14	0.7	1.3	1.7	0.5	35	76	61	79	67
230313002	Portsmouth	Kittery # 2	14	0.5	1.0	1.6	0.5	31	36	67	77	70

Table 3-5. Highest-density Type 2 sites by PAMS nonattainment area.

Site Code	PAMS Area	State	# 50Km	# 100Km	# 300Km	# 500Km	Density Rank
060371002	S. Co./SEDAB	CA	2	3	7	8	88
250092006	Boston	MA	1	3	7	9	80
090031003	Connecticut	CT	1	2	9	11	79
482010026	Houston	TX	2	2	4	7	69
250130008	Springfield	MA	1	1	7	10	63
421010004	Philadelphia	PA	1	1	6	11	63
360050083	New York	NY	0	1	9	11	58
061113001	Ventura County	CA	0	2	8	8	57
440071010	Providence	RI	0	2	7	9	57
060730003	San Diego	CA	1	1	6	8	56
230313002	Portsmouth	ME	0	2	6	8	52
482450009	Beaumont/Port Arthur	TX	1	1	5	7	51
060290010	San Joaquin	CA	0	0	6	10	40
481130069	Dallas	TX	1	1	1	6	37
240053001	Baltimore	MD	0	1	4	7	35
060670006	Sacramento	CA	1	1	2	3	33
170310072	Lake Michigan	IL	1	1	2	2	31
110010043	Washington	DC	0	1	3	6	30
130890002	Atlanta	GA	1	1	1	1	26
220330009	Baton Rouge	LA	0	0	2	5	17
040139997	Phoenix	AZ	0	0	0	3	7
481410044	El Paso	TX	0	0	0	0	0

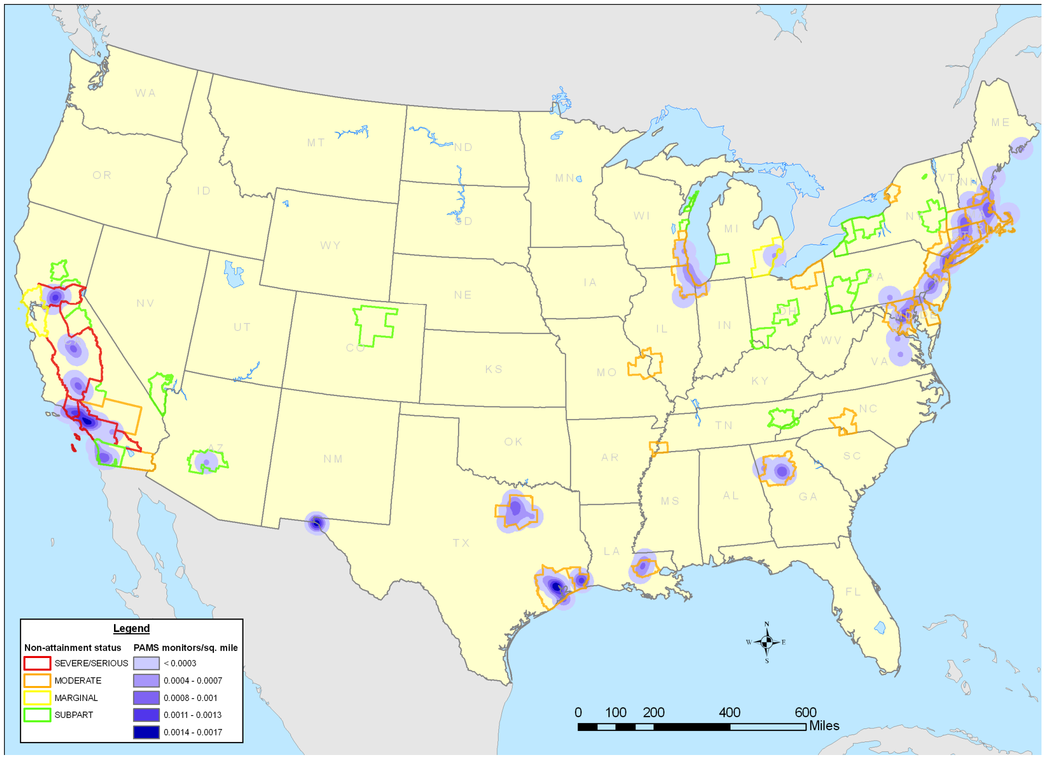

Figure 3-1. Density of the PAMS network.

Finally, an analysis of data quality was performed. **Figure 3-2** illustrates the maps used to visually inspect MDLs and the percentage of data below MDL. Regions where more than 50% of samples were below detection include the SJV, Dallas, and sites in Maine. While this result might be reasonable for the far downwind Maine sites where hydrocarbon precursor concentrations are expected to be low, it is surprising that in two areas with the highest ozone and precursor concentrations, hydrocarbon concentrations cannot be adequately quantified at most sites more than 50% of the time.

Secondly, MDLs ranged by about an order of magnitude among the PAMS sites. In general, the Northeast sites had the lowest MDLs, while California and Texas sites were higher. This difference indicates that improved quantification of PAMS species is technically feasible in areas where detection rates are particularly low and MDLs are high.

The Trends Length analysis identifies the number of years a monitoring site has been operating and measuring specific PAMS precursor species. While this analysis is important within regions for identifying which monitoring sites may be valuable for assessing pollutant trends, it is not as useful on the national level for comparison among regions. At a national level, the overwhelming majority of nonattainment areas have some monitors with records of sufficient length to perform a meaningful trends analysis (i.e., five or more years of data).

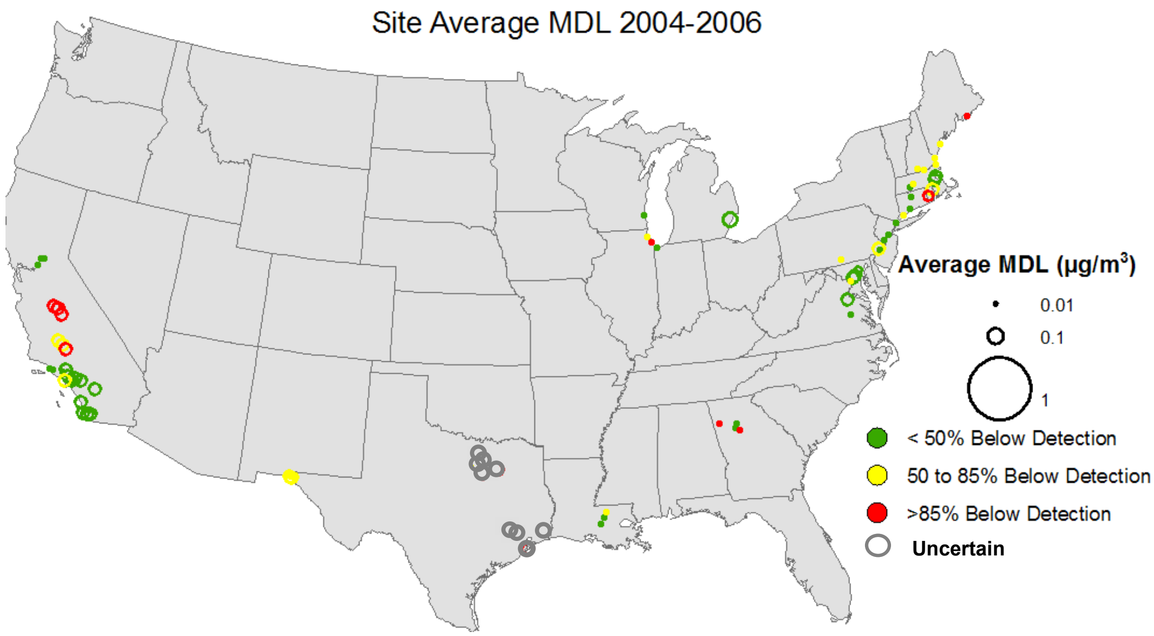

Figure 3-2. Average MDL at PAMS monitors for n-octane from 2004-2006. Symbol sizes reflect the MDL concentrations and colors indicate the fraction of data below the reported MDLs.

Findings:

- High precursor concentration areas include the SoCAB and SJV, California; Houston and El Paso, Texas; Baton Rouge, Louisiana; New York; and Connecticut.
- Low precursor concentration areas include the upper Northeast and Sacramento, California.
- High-density monitoring networks are located in Southern California, the upper Northeast, and Houston.
- Monitoring networks in Atlanta, Georgia; El Paso; Phoenix, Arizona; and Baton Rouge are low density.
- Data quality is poor in the SJV and at non-Type 2 sites in Texas due to high MDLs.
- MDLs are high throughout California and non-Type 2 sites in Texas.

3.1.3 Emissions Tracking

From the perspective of accountability, tracking changes in emissions precursors over time is an important PAMS objective to provide information for policy makers about the sources of ozone precursor emissions and how emissions are changing. The number of parameters measured at a site is a reasonable proxy for determining how useful a site is for performing source apportionment of precursors to assess source contributions. The number of samples collected is also a reasonable proxy for determining if a data set is large enough to perform source apportionment. Finally, the emissions inventory analysis is useful for evaluating a monitoring sites' ability to capture major sources of hydrocarbons and NO_x.

Sites in PAMS nonattainment areas measured parameters sufficient for tracking emissions. The PAMS suite of hydrocarbons alone is typically sufficient to perform source apportionment. Within regions however, the monitors most likely to be chosen for source apportionment were identified.

Nationally, there are some areas—Atlanta, Dallas, and Houston—where Type 2 sites are located in areas of low emissions density based on National Emission Inventory (NEI) estimates; however, the measured concentration analyses for these sites show that ozone precursor concentrations are reasonably high. Consequently, the NEI estimates in these areas are likely under-representing actual emissions patterns; we, therefore, have little confidence in the emission inventory analysis results.

Findings:

- Sites in all PAMS areas are useful for source apportionment and emissions tracking.

3.1.4 Ambient Trend Appraisals

Most nonattainment areas have relatively long trend lengths that should be more than adequate to assess changes in ozone and precursors over time, assuming the data are comparable over time and of good quality. In the regional analysis, these sites are identified as the most important for long-term trend analysis by nonattainment area.

The areas from which fewer than five years of speciated hydrocarbon data are available are Phoenix; Allegan County, Michigan; and New Hampshire. Other individual monitoring sites from which less than five years of data are available are noted in the regional analysis discussions.

At a national level, overarching findings include data quality and data availability issues. Data quality affects trends analysis because the concentrations over time become less quantifiable as the fraction of data below MDL increases. In this case, the trend may be decreasing, but the certainty decreases in the rate and absolute value of the change. For some pollutants, it may become impossible to estimate the change in concentration over time. Theoretically, these levels will be below the level at which they contribute significantly to ozone formation.

Findings:

- Almost all PAMS areas had sites suitable for long-term trend analysis.
- The large fraction of data below MDL in the SJV will make trend analysis difficult and will yield questionable results.

3.1.5 Exposure Assessment

The PAMS monitoring network is intended to support exposure assessment efforts. PAMS sites include ozone and NO_x measurements which are often used for exposure assessments. In addition, PAMS measure hazardous air pollutants (HAPs or air toxics) such as benzene, toluene, and xylenes among the speciated hydrocarbons. Exposure assessments can benefit from large numbers of pollutants measured at multiple sites within an area, as this allows comparisons across populations. Areas where large numbers of parameters are monitored at multiple sites are listed in **Table 3-6**:

Table 3-6. Areas where large numbers of parameters are monitored at multiple sites.

PAMS Area	Number of Sites and Parameters
Phoenix	2 sites with 207 and 164 pollutants, respectively
Greater Chicago area	2 sites with 239 and 186 pollutants, respectively
Baltimore area	2 sites with 167 and 153 pollutants, respectively
Philadelphia area	2 sites with 189 and 166 pollutants, respectively
New York area	2 sites with 172 and 171 pollutants, respectively
Dallas	2 sites with 184 and 165 pollutants, respectively
Houston	4 sites with 220, 179, 164, and 162 pollutants

Areas that may also be of interest for exposure assessment include those where measured concentrations of air toxics in the PAMS network are particularly high. Among the PAMS target list, only benzene, 1,3-butadiene, acetaldehyde, and formaldehyde are typically at concentrations of concern to human health (McCarthy et al., 2007). Of these pollutants, the highest morning concentrations of benzene are shown in **Figure 3-3** and the afternoon concentrations of acetaldehyde are shown in **Figure 3-4**. Morning concentrations of benzene were highest in El Paso, Houston, and Beaumont Texas; Baton Rouge, Louisiana; Los Angeles, California; and two sites in the industrial Midwest.

1,3-Butadiene is only measured routinely in a few states, and the vast bulk of those measurements are made in Texas and Louisiana. Formaldehyde and acetaldehyde are typically measured only at maximum precursor emissions sites. Concentrations of these pollutants were higher in Southern California and parts of Texas and at a site in Indiana. Formaldehyde patterns were very similar to acetaldehyde patterns.

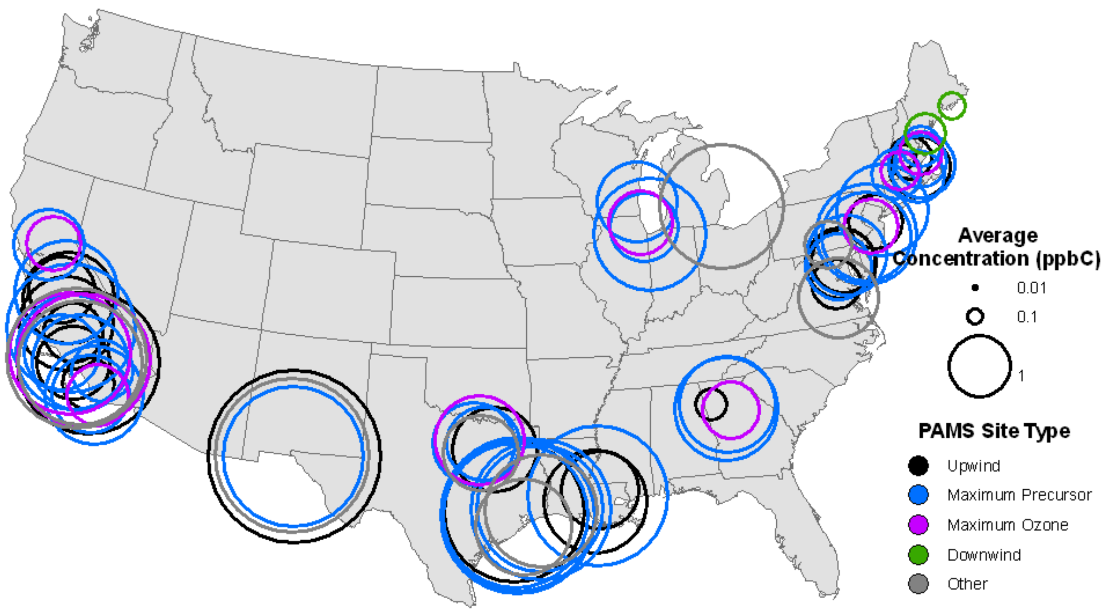

Figure 3-3. Benzene concentrations (ppbC) for 6-9 a.m. 2004-2006 at all PAMS sites.

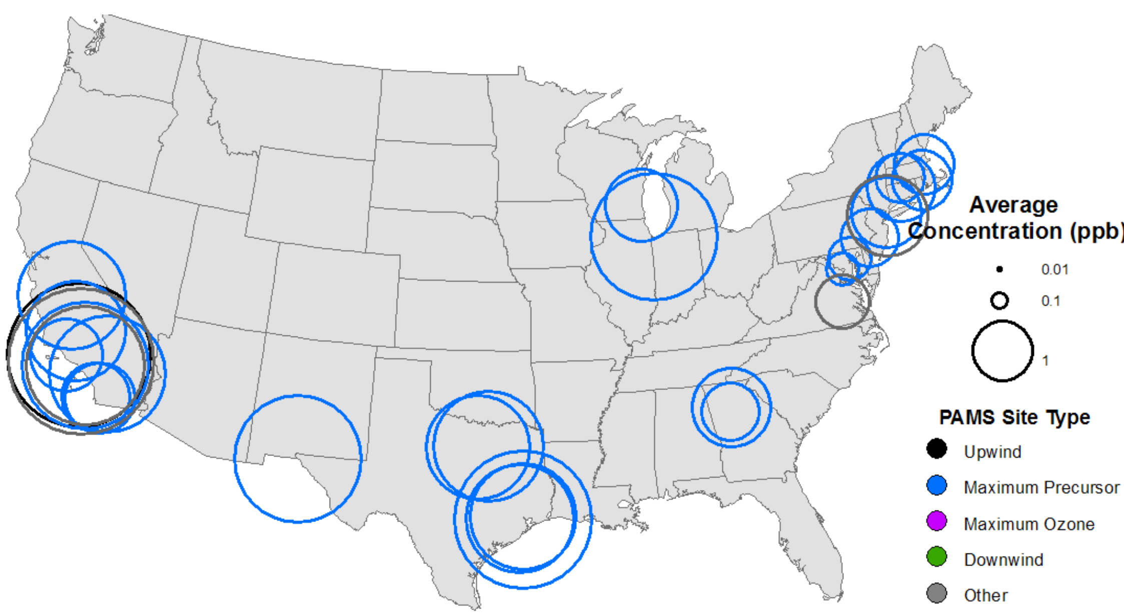

Figure 3-4. Afternoon acetaldehyde concentrations (ppb) for 12-3 p.m. 2004-2006 at all PAMS sites.

Findings:

- The highest concentrations of benzene are in Texas and parts of Southern California and at isolated sites in other areas.
- The highest concentrations of acetaldehyde are in Southern California and Texas and at a site in Indiana.
- Assuming data quality is good, sites at which more parameters are measured are the most useful for exposure assessments.

3.2 FINDINGS BY SITE TYPE

3.2.1 Type 1 – Upwind Sites

Type 1, or upwind, sites are intended to capture ozone precursor concentrations transported into an urban area. These concentrations are an important background constraint for evaluating the portion of the area's ozone that originates from local emissions versus transported upwind emissions. These types of monitors can serve a dual purpose in heavily urbanized areas like the Northeast where an upwind site for one city is a downwind site for another. In cases where sites are classified as both upwind and downwind, we may expect relatively high concentrations of pollutants being transported, relative to those sites which are measuring less polluted upwind concentrations.

For upwind areas originally separated from the urban boundaries, there is a concern that these monitoring sites may now be influenced by local emissions as a result of metropolitan area growth. Therefore, concentrations at some Type 1 monitors may no longer represent the concentrations being transported alone. In this subsection, Type 1 sites are examined to see if they are still meeting the monitoring objective of providing upwind concentrations for the urban core.

The following analyses were used to evaluate how well upwind sites were meeting their monitoring objectives: Measured Concentrations, Data Quality, Emission Inventory, and the Maximum Ozone analysis. Results for upwind sites were treated differently for sites that were also classified as maximum ozone sites (i.e., Type 1/3). When a site is dual-purpose, it may not be suitably evaluated as a Type 1 site alone. Those cases were evaluated separately from the Type 1-only sites.

Three questions were addressed for the national Type 1 sites:

1. Are measured concentrations of NO_x and hydrocarbons lower at Type 1 sites than at maximum precursor sites in the same area?
2. Are emissions of NO_x and hydrocarbons low (relatively and absolutely) for these sites?
3. Are 8-hr ozone concentrations low at a Type 1 site compared to other sites in the area?

Nationally, only the third question can be answered affirmatively for virtually all sites and regions. Ozone concentrations at upwind sites are always lower than those at other sites in the nonattainment area for exclusively designated Type 1 sites. The answers to the first two questions vary.

Either relatively or absolutely high measured morning concentrations of NO_x and/or VOC precursors are measured at some nonattainment area upwind sites. Moreover, these same areas often appear to experience high emissions (absolutely or relatively) of the same pollutants. These areas will be specifically noted in Section 4, Region-specific Findings and Recommendations.

Using available data, most Type 1 sites appear to be located in areas that are appropriate or in areas with relatively low source impact for a nonattainment area. Further evaluation of the current location of some Type 1 sites for Baton Rouge, Dallas, El Paso, Houston, New York, and the SoCAB may be warranted.

Findings:

- Some Type 1 sites appear to be capturing concentrations that may reflect local emissions rather than transported concentrations.
- Type 1 sites typically experience lower ozone concentrations than do other sites in nonattainment areas. Note that Type 1/3 sites were not included in this type of analysis.

3.2.2 Type 2 – Maximum Precursor Emission Sites

Type 2, or maximum precursor, monitoring sites primarily focus on capturing the precursor concentrations emitted in an urban area. These monitors are sited to capture the local mix of emissions and are used to evaluate the source types and magnitudes of local emissions. These sites should be near areas of high emissions density and experience high concentrations of hydrocarbon and NO_x precursors. Because of high fresh concentrations of emissions, the expectation is that these sites will record relatively low concentrations of ozone because of titration.

The following questions were addressed to assess maximum precursor sites nationally:

1. Are measured concentrations of NO_x and hydrocarbons high (relatively or absolutely)?
2. Are emissions of NO_x and hydrocarbons high (relatively or absolutely)?
3. Do these sites measure the largest number of pollutants for source apportionment?
4. Is data quality sufficient at these sites to perform source apportionment?

Nationally, the results indicate that most Type 2 sites were appropriately located to meet the monitoring objectives as specified by these four questions. Type 2 sites almost universally measured the highest concentrations of hydrocarbons and NO_x in a nonattainment area. Similarly, most Type 2 sites were clearly located in an area of high precursor emissions. The quality of data from a few isolated sites was insufficient, characterized by more than 50% of measurements below the MDL. Many of the Type 2 sites measured large numbers of parameters, as expected. Overall, the Type 2 sites appear to be meeting their objectives nationally.

Among sites or nonattainment areas for which the answer to one or more of the four questions was negative, the most common problem was that the precursor emission concentrations were low on an absolute scale. In other words, while concentrations at a maximum precursor emission site were the highest measured within a nonattainment area, they were not high relative to precursor concentrations nationally. Assuming the methodology of comparing nonattainment areas is not the primary cause for this difference, these areas may be further along in the reduction of local precursor emissions. However, the simple analysis performed ignores possible differences that might result from different morning sampling times and/or durations, PAMS seasonal variations, and any geographical/meteorological features that might enhance or reduce pollutant concentrations. Areas with low absolute concentrations included Boston, Massachusetts; East Hartford, Connecticut; New Hampshire; and Rhode Island.

Type 2 maximum precursor emissions sites in some areas experienced lower concentrations than did other site types in the area. These areas are specifically noted in the regional analysis. Similarly, Type 2 sites in a few areas had poor data quality. Type 2 sites are characterized by high local concentrations and should not have difficulty generating a data set where 50% of the samples show concentrations above the MDL. Finally, the Type 2 sites were heavily instrumented and more than a dozen nonattainment areas had at least one site that measured more than 150 individual pollutants during the 2004-2006 time frame. These sites are excellent candidates for sophisticated source apportionment analysis.

Findings:

- High relative precursor concentrations occur at most Type 2 sites.
- Most Type 2 sites appear to be located in areas of high emissions based on the somewhat qualitative emissions inventory analysis.
- Many Type 2 sites provide large numbers of collocated measurements.
- Type 2 sites in the SJV indicate data quality problems.
- There are several areas with a high density of Type 2 sites.

3.2.3 Type 3 – Maximum Ozone Concentration Sites

Type 3, or maximum ozone concentration, sites primarily focus on capturing the precursor concentrations at the area of highest ozone concentrations downwind of the urban area. Precursor concentrations at these sites capture the mix of aged and local emissions to determine the degree of photochemical aging that has occurred as pollution is transported downwind. These sites should be located in the areas of maximum ozone concentrations and, because of possible titration, not be located in high NO_x concentration/emission areas. It is possible that some Type 3 sites are no longer situated in appropriate locations to meet their original monitoring objectives because of the change in the ozone standard from a 1-hr to an 8-hr standard and because of urban development in areas formerly outside urban boundaries.

The following questions were addressed to assess maximum precursor sites nationally:

1. Are measured concentrations of 8-hr ozone on days exceeding 75 ppb highest at (or near) the Type 3 sites?
2. Are Type 3 sites in or near an area where the number of days of 8-hr ozone exceedances is highest?
3. Are morning concentrations of NO_x high (relatively or absolutely)?

As expected, these analyses showed that many of the areas currently deemed maximum ozone concentration sites do not actually experience the highest ozone concentrations, or the highest number of exceedances of ozone with an 8-hr, 75 ppb ozone standard. When the Type 3 sites were examined to see if the highest ozone concentrations occurred on days when at least one site exceeded 75 ppb, more than half the sites were unequivocally located away from the area of maximum ozone concentrations. About one-third were located in areas of the maximum ozone concentrations.

In a second analysis to examine the total number of days with ozone concentrations above 75 ppb occurring at a site, a little more than half the sites were at or near the areas where the most values above 75 ppb were recorded. While Type 3 sites were not usually those with the highest number, they were often spatially close to the maximum site or recorded a slightly smaller number of days when concentrations were above 75 ppb (<5 difference). However, about one-third of nonattainment areas had Type 3 maximum ozone sites that were not located near the maximum ozone sites and did not have the highest number of days above 75 ppb. These areas are discussed in detail in Section 4, Region-specific Findings and Recommendations.

Finally, an analysis of morning NO_x concentrations at the Type 3 sites revealed that high absolute concentrations of NO_x occurred at only a few sites. Seven of the sites designated Type 3 measured average morning NO_x concentrations above 30 ppb, which was the national average morning concentration across all sites. Of these seven sites, five also recorded high morning hydrocarbon concentrations. These two factors suggest that these sites are likely to be influenced by fresh emissions and may need to be relocated or repurposed; they are discussed in Section 4, Region-specific Findings and Recommendations. About 60% of the Type 3 sites were below the median NO_x concentration and do not appear to be unduly influenced by fresh morning emissions of NO_x. Overall, this analysis is consistent with the previous two analyses, suggesting that some monitoring sites may not be accurately positioned to measure maximum ozone concentrations nationally.

Findings:

- Most Type 3 sites appear to be improperly located, that is, they are not located in areas of maximum 8-hr ozone concentrations.
- Nationally, maximum ozone concentrations appear to be occurring in areas downwind of the PAMS Type 3 sites or outside the PAMS urban area.
- A small number of Type 3 sites appear to be impacted by fresh local emissions, characteristic of Type 2 sites.

- The Type 3 sites are often spatially near the maximum measured ozone concentrations (as determined by highest concentrations and number of days when 8-hr maximum ozone concentrations are greater than 75 ppb) but are usually closer to the urban core than the maximum ozone sites.

3.2.4 Type 4 – Far Downwind Sites

Type 4, or far downwind, sites are designed to capture the precursor concentrations at areas far downwind of an urban area. Precursor concentrations at these sites represent photochemically aged emissions. Only four active Type 4 sites exist in the entire network. Of these, two sites are classified as both Type 1 and Type 4 (Type1/4) sites and probably do not represent far downwind concentrations. As a result, it would be appropriate to reclassify these sites.

Two questions were addressed for the two Type 4 sites:

1. Are precursor concentrations low?
2. Are the data of sufficient quality to assess photochemical transformation?

The two active Type 4 sites both exhibit very low concentrations of hydrocarbon and NO_x precursors. In addition, both report slightly more than half their concentrations above MDL. This is quite impressive given the very low concentrations of VOCs and NO_x measured at the sites relative to other areas. These two sites are meeting their objectives well.

Findings

- Type 4 sites appear to be meeting their objectives well.
- Type 1/4 sites should be reclassified as Type 1/3 sites.

3.3 NATIONAL NETWORK RECOMMENDATIONS

- The original list of PAMS areas no longer reflects ambient ozone problem areas. Consider redesignating serious ozone areas based on the current 8-hr ozone standard. The recommendations provided by Region 5 (Section 4.5.3) are excellent options for implementing this change.
- The most serious nonattainment areas are in California. Current PAMS monitoring in the Sacramento and SJV areas appears to be inadequate. The SoCAB appears to have sufficient monitoring resources, but may need to move some of its current monitors farther downwind into Riverside and San Bernardino. The lack of suitable ozone monitoring is at least partially due to the California Alternative Plan (CAP) sites re-purposing as air toxics sites.
- The second most serious nonattainment areas are in Texas. The number of monitors in Houston and Dallas appear adequate, although some monitors may need to be relocated.

- Isolated monitoring networks in Phoenix, Atlanta, El Paso, Baton Rouge, and Lake Michigan are close to the minimal possible size to characterize local ozone and precursor emissions.
- The mid-Atlantic to Northeast monitoring networks contain a disproportionate number and density of monitors given the magnitude of the ozone problems in these areas. However, these areas are also densely populated, and the magnitude of population exposure was not considered in this study. Redundancy analyses should be performed for sites in these areas to determine if any monitors can be removed without losing valuable information. Low ozone and precursor concentrations in the New England area do not appear to justify the large number of monitors.
- Data quality is a region-specific issue that is reducing the value of PAMS measurements. National-scale requirements for MDL values should be strengthened to reflect the lower precursor concentrations routinely being observed. Reported MDLs are high throughout California and at non-Type 2 sites in Texas and can be lowered to improve data quality.
- Many sites are not meeting the monitoring objectives of their site type. This is particularly true for Type 3 maximum ozone sites which should generally be located further downwind of urban areas. Regional analyses should follow on the analyses performed in this study to identify whether sites are properly located to meet monitoring objectives on a regional level.
- Dual Type 1/4 sites do not appear to be appropriately classified and should be reclassified as Type 1/3.
- The monitoring objective of control strategy evaluation was less thoroughly covered by these analyses than other objectives. Since control strategy evaluation is a necessary component of policy development, future region-specific analyses should better address the network's capability to address control strategy evaluation.

4. REGION-SPECIFIC FINDINGS AND RECOMMENDATIONS

Region-specific analysis results (including comments and feedback from individual regions when provided), relevant notes and information shared during the workgroup meetings, and stakeholder input and feedback are discussed in this section. Stakeholder input is shown in Arial font. Recommendations for additional region-specific analyses are included.

4.1 REGION 1 – NEW ENGLAND

4.1.1 Overview

Region 1 comprises Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island. Ozone nonattainment areas include greater Connecticut; Boston (eastern Massachusetts) and Springfield (western Massachusetts); Boston-Manchester-Portsmouth; Providence, Rhode Island; and the New York area that includes parts of Connecticut. All these areas are classified as moderate or below for ozone. Region 1 has 14 active monitoring sites: two Type 1, seven Type 2, two Type 3, two Type 1/3, and two Type 4.

4.1.2 Region 1 Key Findings

- Region 1 has a moderate-to-low ozone problem, even under the new lower standard. From 2004-2006, the highest sites in the region experienced 10-12 days when ozone concentrations were above 75 ppb (**Figures 4-1 and 4-2**).
- Region 1 experienced the lowest morning concentrations of hydrocarbons and NO_x of any PAMS area (**Figures 4-3 through 4-5**). High morning precursor concentrations occurred only at the New Haven site.
- Boston and Connecticut have one of the densest PAMS networks in the nation.
- The amount of data reported above MDL is very good in Region 1, especially given the low concentrations in the area relative to other PAMS areas.
- All sites in Maine and Rhode Island are suitable for long-term trends analysis; Massachusetts sites at Lynn, Newbury, Chicopee, and Ware are most suitable for trends analysis; and New Hampshire has no sites with long-term data monitoring.
- Site-specific comments are listed in **Table 4-1**.

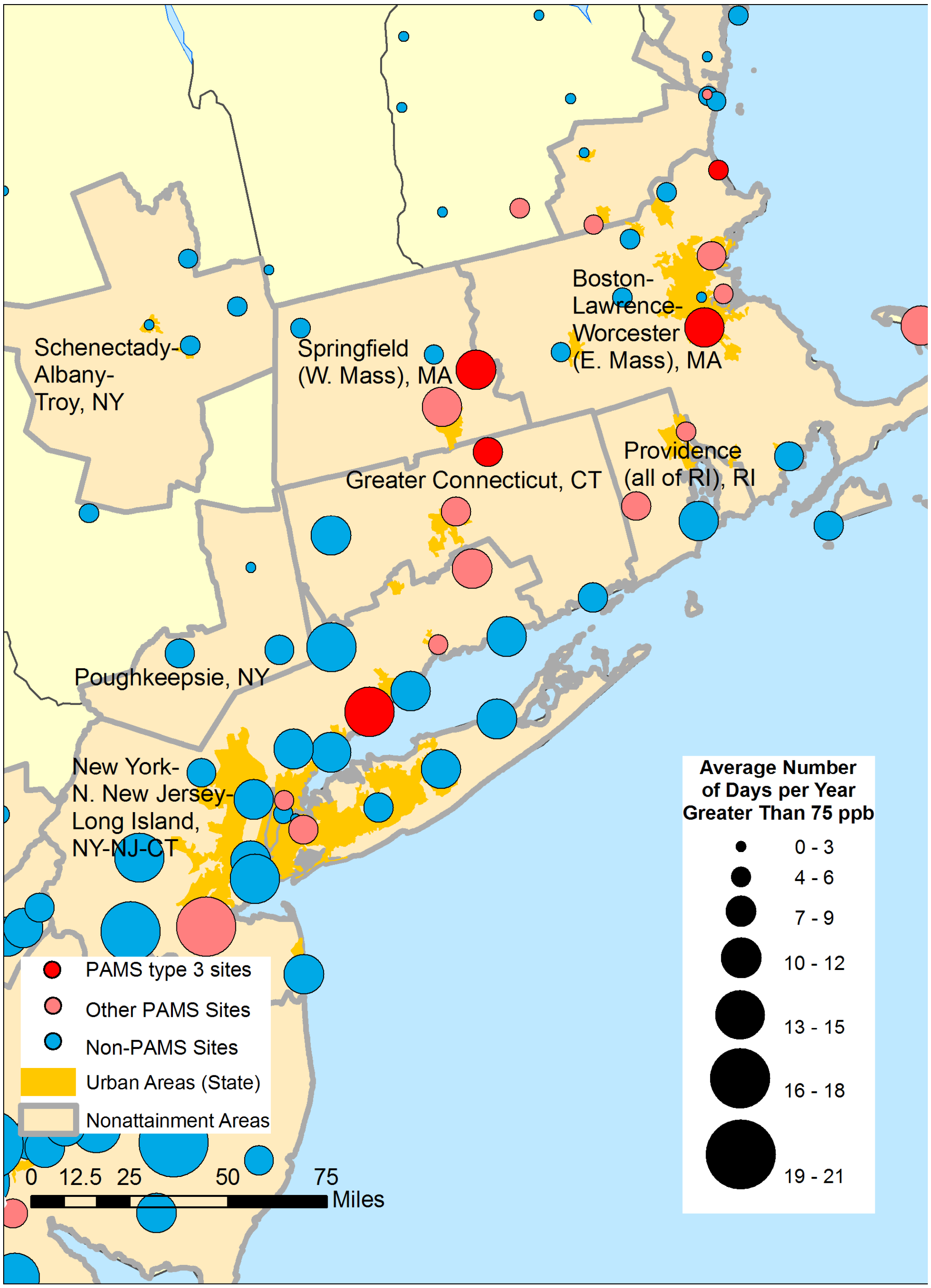

Figure 4-1. Average number of days per year with ozone concentrations greater than 75 ppb from 2004-2006 in Region 1 and parts of Region 2.

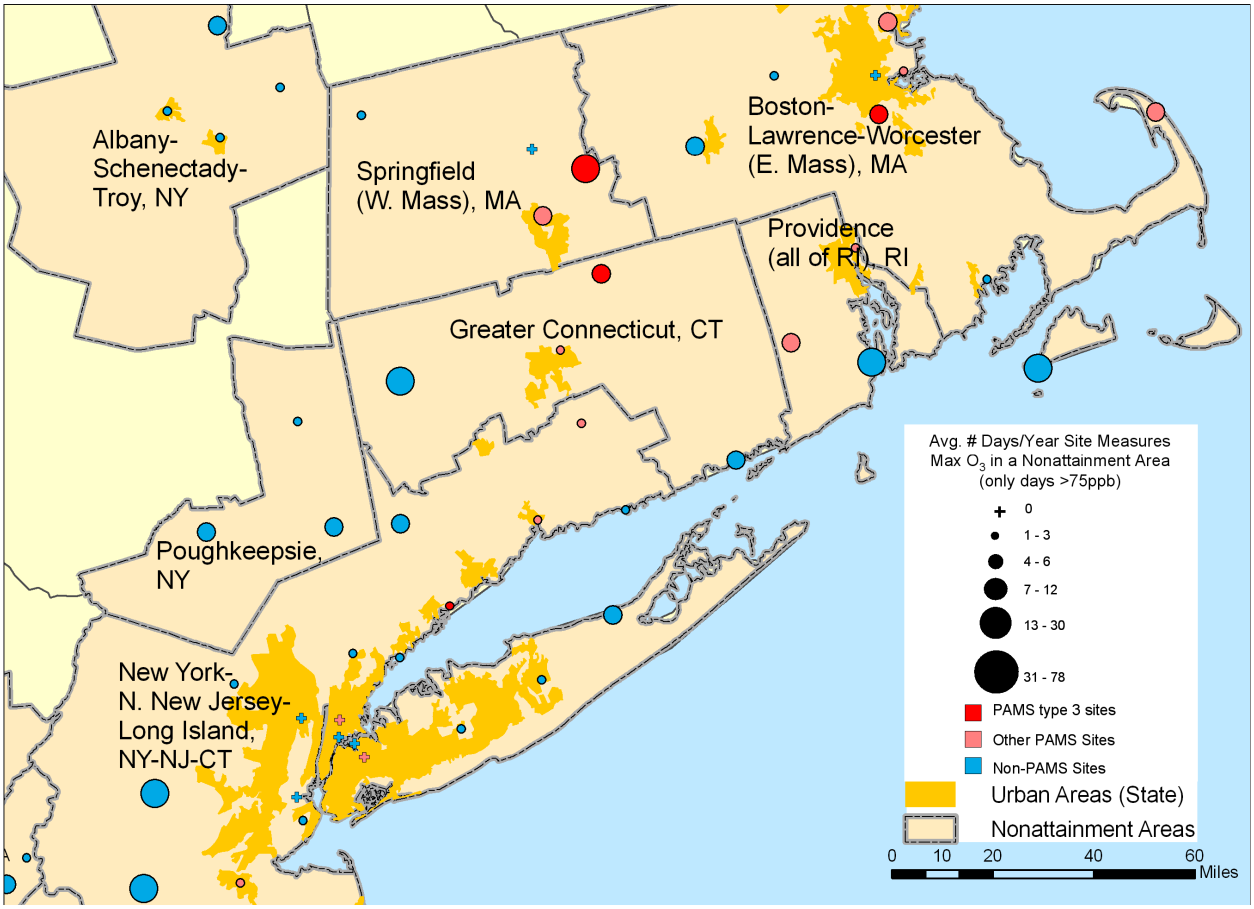

Figure 4-2. Average number of days a site has maximum ozone concentrations greater than 75 ppb in nonattainment areas in Region 1 and parts of Region 2.

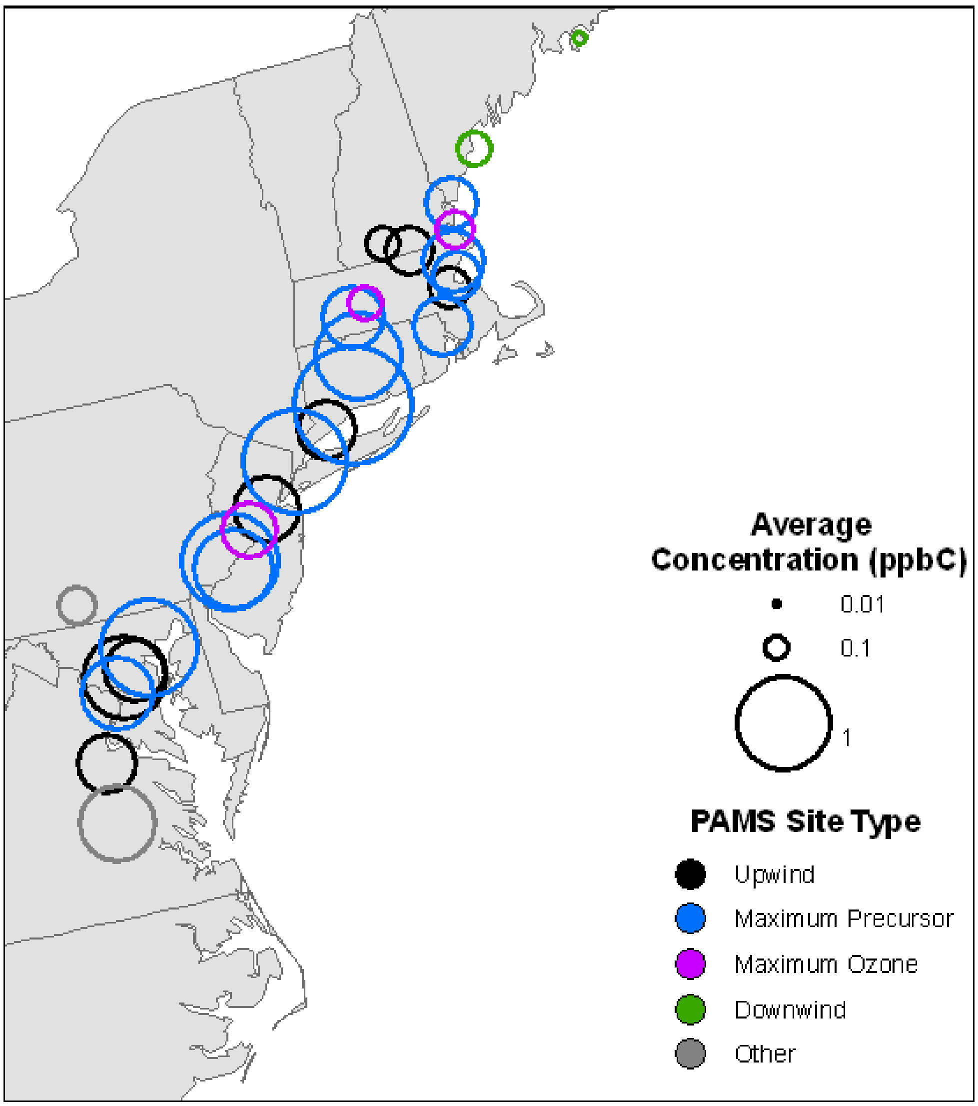

Figure 4-3. Morning ethylbenzene concentrations (ppbC) at northeastern PAMS sites. Region 1 concentrations are the lowest in the Northeast.

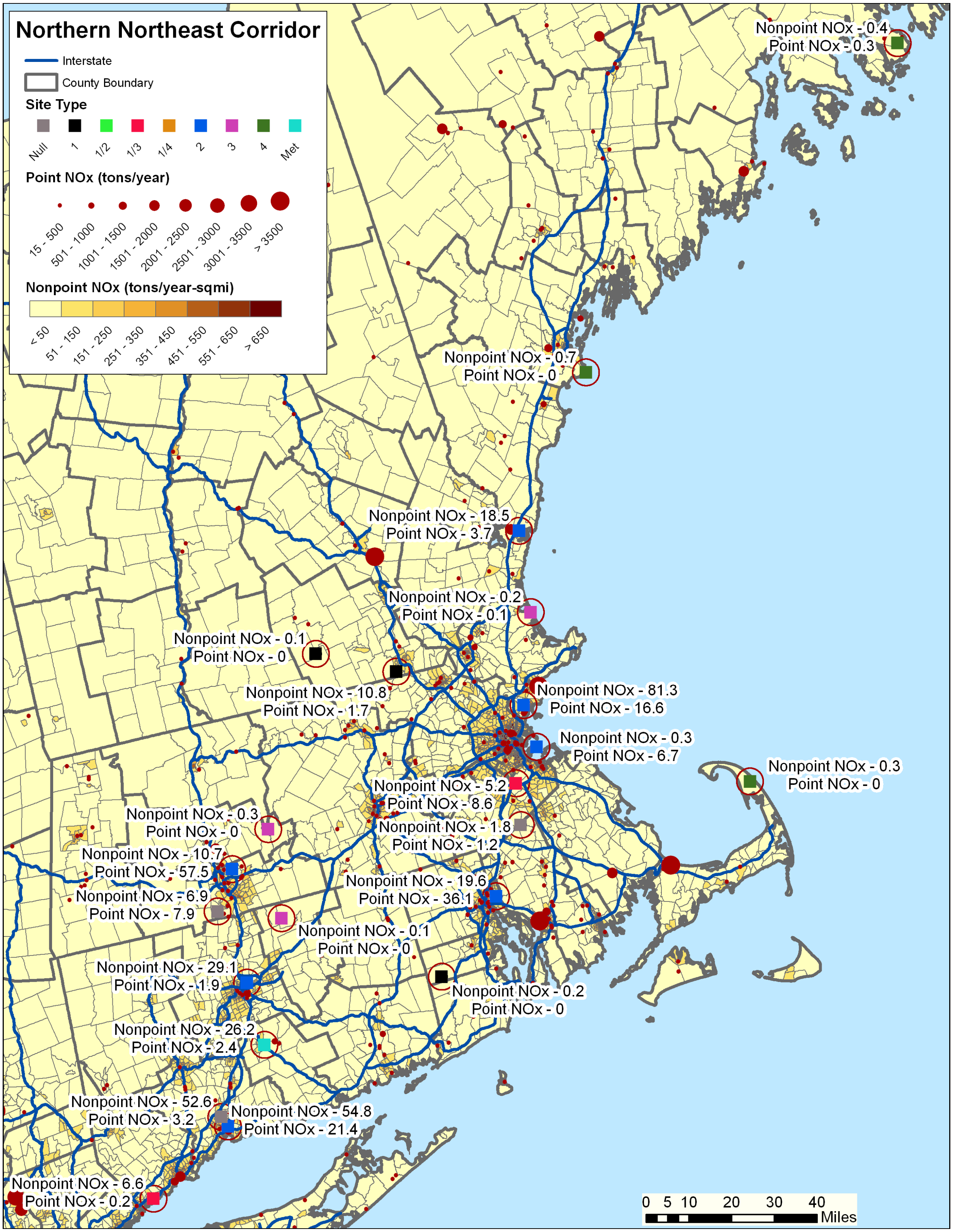

Figure 4-4. Emissions density of NO_x in Region 1 in 2002.

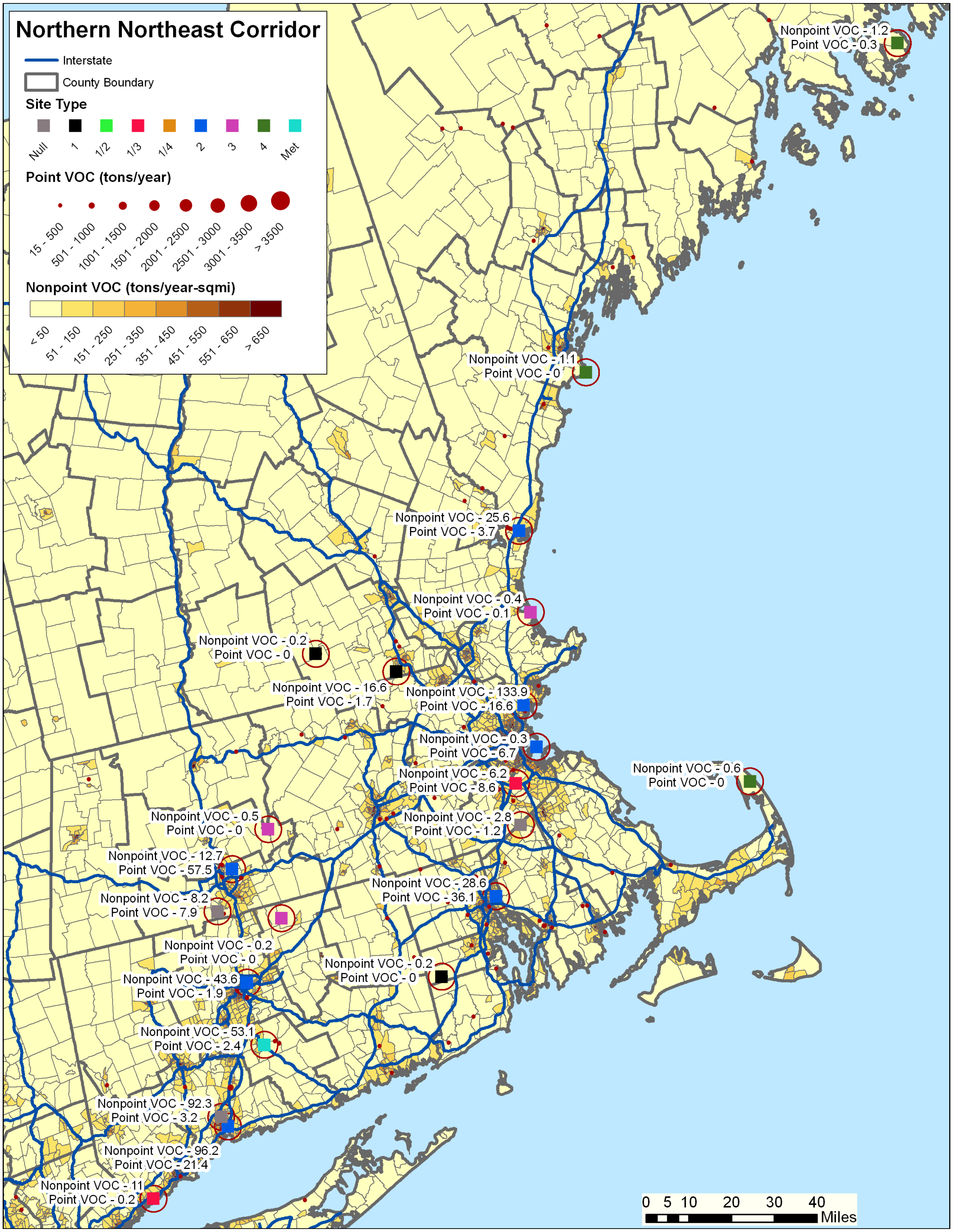

Figure 4-5. Emissions density of VOCs in Region 1 for 2002.

Table 4-1. Region 1 site-specific observations.

Type	Current Site	Analysis Comments
1	NH – Gilson Rd.	High predicted emissions, concentrations about the same as Boston; appears to be more consistent with Type 2 site characteristics.
	NH – Peterborough	Lower concentrations than Gilson Rd.; seems consistent with Type 1.
2	CT – New Haven	Highest concentrations in region; likely most valuable Type 2 site.
	CT – East Hartford	Low concentrations; consider evaluating usefulness of site.
	MA – Chicopee	Low concentrations; consider evaluating usefulness of site.
	MA – Lynn	Low concentrations; consider evaluating usefulness of site.
	MA – Long Island	Low concentrations and low predicted emissions; site may not be consistent with Type 2 objectives.
	RI – Providence	Low concentrations, large number of collocated measurements; valuable site for advanced analyses (i.e., source apportionment, trends assessment, exposure assessment).
1/3	MA – Blue Hill, Milton	Highest number of ozone concentrations >75 ppb in E. MA; consistent with Type 3 site.
	CT – Sherwood	Downwind site for NY, high number of ozone concentrations >75 ppb; consistent with Type 3 site.
3	MA – Newbury	Fewer ozone concentrations >75 ppb than Blue Hill; consider evaluating usefulness of site.
	MA – Springfield	Highest number of ozone concentrations >75 ppb in W. MA; consistent with Type 3 site.
4	ME – Cape Elizabeth	Higher concentrations than Acadia; consistent with Type 4 site.
	ME – Acadia	Lowest concentrations of any site in entire network; consistent with Type 4 site.

4.1.3 Summary of Region 1 Stakeholder Discussion

Insert text here

4.1.4 Regional Recommendations

Region 1 experienced low precursor concentrations at almost all sites. Combined with the low ozone concentrations relative to other areas, the density of maximum precursor and maximum ozone monitors does not appear to be justified. In addition,

- The emission inventory analysis performed in this network assessment is insufficiently detailed for the Region 1. However, a more sophisticated emission inventory analysis may be justified to ensure that the maximum precursor emissions sites are actually to areas of high emissions. Alternatively, it may be useful to perform a short monitoring study to determine where concentrations are highest in the region.
- Redundancy analyses should be performed for sites to determine if they are capturing unique mixtures of sources.

4.2 REGION 2 – NORTHEAST

4.2.1 Overview

Region 2 comprises New York, New Jersey, Puerto Rico, and the Virgin Islands. Ozone nonattainment areas include New York-New Jersey-Long Island, Jefferson County, Poughkeepsie, Rochester, Albany, Buffalo, Essex County, and Jamestown. All these areas are classified as moderate or subpart 1 for ozone. Region 2 has four active monitoring sites: two Type 2, one Type 3, and one Type 1/4.

4.2.2 Region 2 Key Findings

- Region 2 has a moderate ozone problem under the new standard. From 2004-2006, the site with the highest ozone concentrations in the region experienced 20 days of ozone concentrations greater than 75 ppb on average (Figures 4-1 and 4-2).
- Region 2 has precursor emission sites that measured the highest precursor concentrations along the Northeast corridor in the Camden and Bronx Botanical Garden Sites (**Figure 4-6**).
- Region 2 has a moderate high-density ranking, although very few PAMS sites are actually in Region 2.
- Very little data are reported below MDL in Region 2.
- All sites in Region 2 are suitable for trends analysis.
- The highest ozone concentrations appear to be outside the PAMS monitoring network corridor. Ozone concentrations are higher inland in New Jersey and closer to the Atlantic Ocean in New Jersey. Inland or coastal monitoring sites in this area may be needed to capture the precursor mix in these areas.
- Site-specific observations are provided in **Table 4-2**.

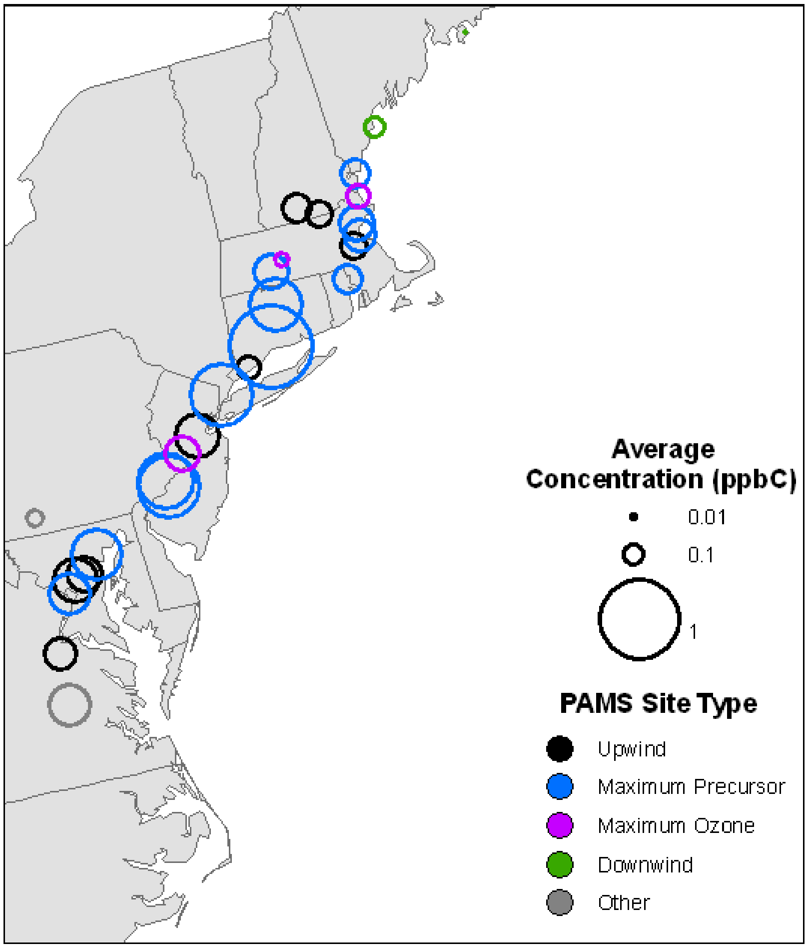

Figure 4-6. Morning n-octane concentrations (ppbC) in the Northeast at PAMS sites. Region 2 concentrations are among the highest in the Northeast.

Table 4-2. Region 2 site-specific observations.

Type	Current Site	Analysis Comments
1/4	NJ – New Brunswick	Highest ozone concentrations in region; data indicate that the site is more characteristic of a Type 1/3 site.
2	NJ – Camden	Relatively high precursor concentrations for the Northeast; consistent with Type 2 site characteristics.
	NY – Bronx	Relatively high precursor concentrations for the Northeast; consistent with Type 2 site characteristics.
	NY – Queens	Discontinued as PAMS VOC site.
3	Rider College	No longer in area of highest ozone concentrations; consider moving or reclassifying the site.

4.2.3 Summary of Region 2 Stakeholder Discussion

Insert text here

4.2.4 Regional Recommendations

- This area may benefit from locating PAMS maximum ozone sites inland and coastally to better capture the highest ozone concentrations in the region. Further spatial analysis of high ozone concentrations in the region may lead to placing an additional PAMS monitor further inland to capture the areas of maximum ozone.
- Consider relabeling New Brunswick a Type 1/3 site. Consider moving Rider College site or redesignating.

4.3 REGION 3 – MID-ATLANTIC

4.3.1 Overview

Region 3 comprises Delaware, Washington DC, Maryland, Pennsylvania, Virginia, and West Virginia. Ozone nonattainment areas include Baltimore, Philadelphia-Wilmington-Atlantic City, and Washington DC. All these areas are classified as moderate ozone areas. Region 3 has seven active monitoring sites: one Type 1, four Type 2, and two Type 1/3.

4.3.2 Region 3 Key Findings

- Region 3 has a moderate ozone problem under the new standard. From 2004-2006, site with the highest ozone concentrations in the region experienced 20 days of ozone concentrations greater than 75 ppb on average (**Figures 4-7 and 4-8**).
- Region 3 has somewhat lower concentrations of hydrocarbon and NO_x precursors than does Region 2 (**Figure 4-9**). The Region 3 concentrations equal the national average.
- The density of the network in the Mid-Atlantic ranges from moderately high in the Philadelphia region to moderately low in the Washington DC area.
- The amount of data reported above MDL is very good in Region 3.
- The McMillan (Washington DC), Essex and Fort Meade (Maryland), E. Lycoming (Pennsylvania), and Corbin (Virginia) sites are likely suitable for trends analysis.
- The Essex, McMillan, and E. Lycoming sites are all good candidates for source apportionment.
- **Figures 4-10 and 4-11** may be helpful in reviewing site objectives, but emission information was inadequate to complete an assessment of emissions impact at the site.
- Sites specific observations are provided in **Table 4-3**.

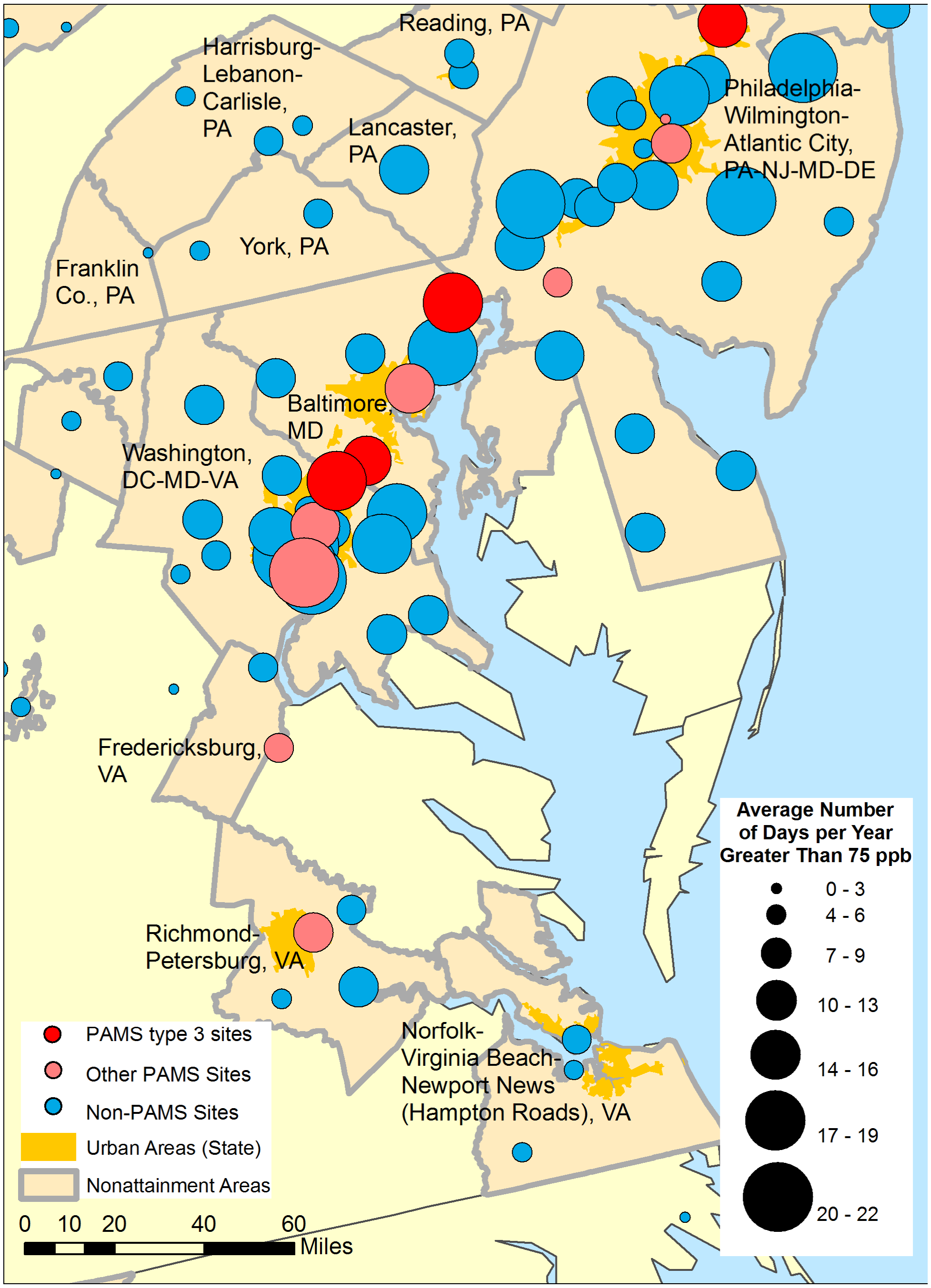

Figure 4-7. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Region 3.

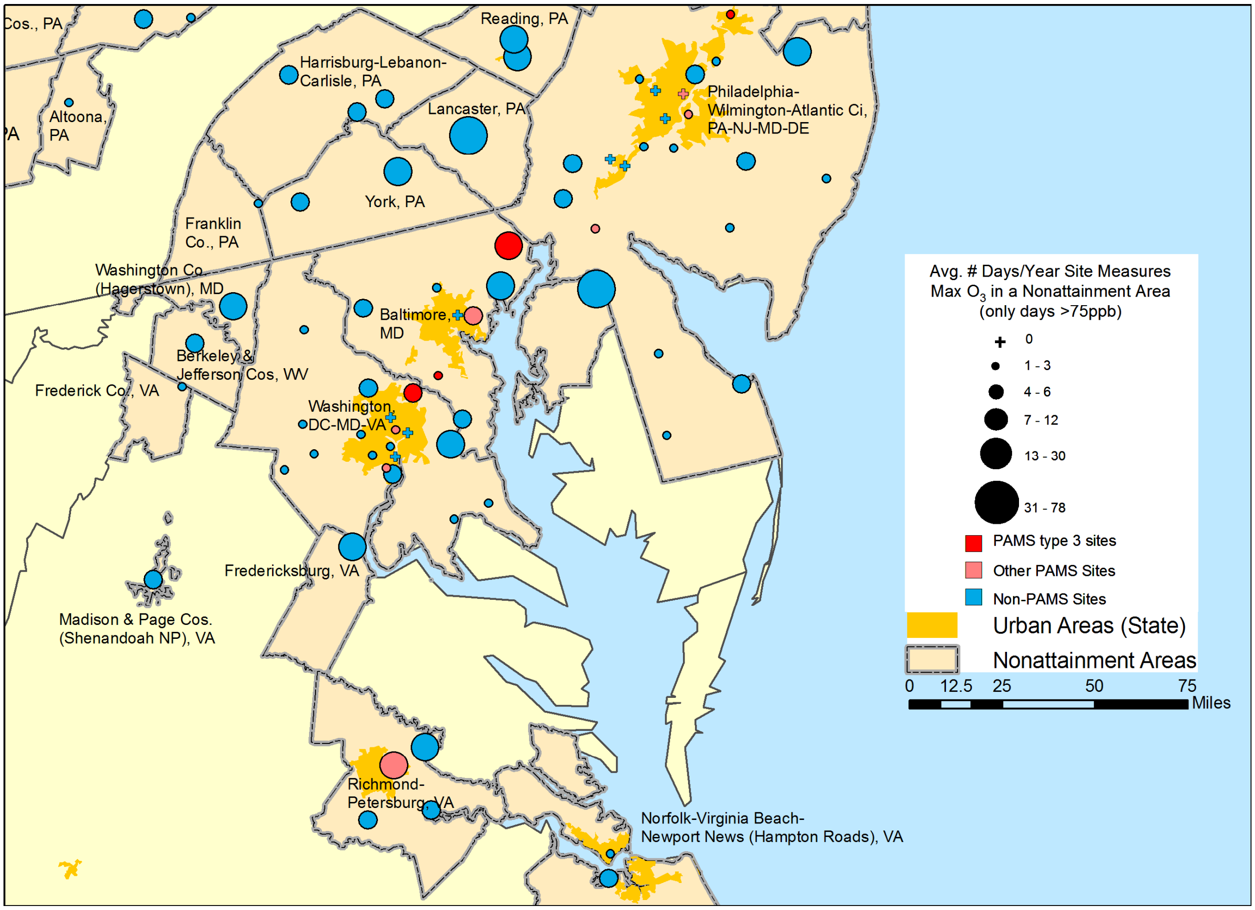

Figure 4-8. Average number of days a site experienced maximum ozone concentrations greater than 75 ppb in nonattainment areas in Region 3.

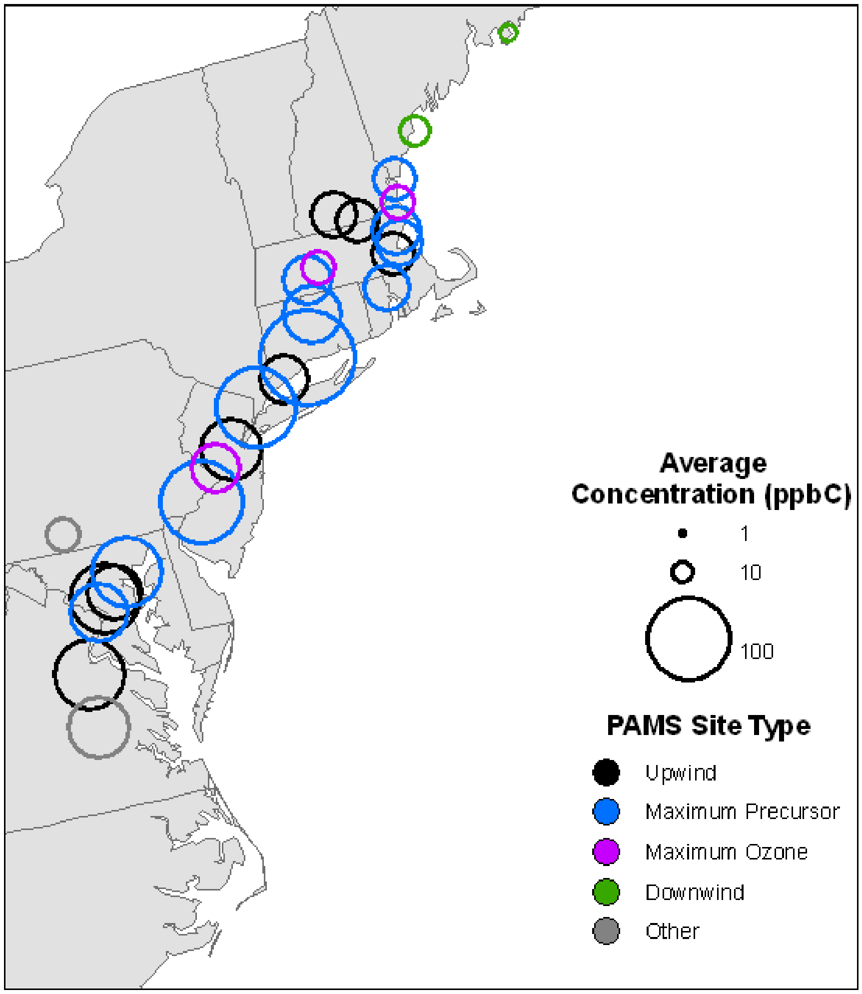

Figure 4-9. Morning sum of PAMS target compound concentrations (ppbC) in the Northeast corridor (Regions 1-3) at PAMS sites. The average sum of PAMS concentrations in Region 3 is higher than in Region 1, but lower than in Region 2 precursor sites.

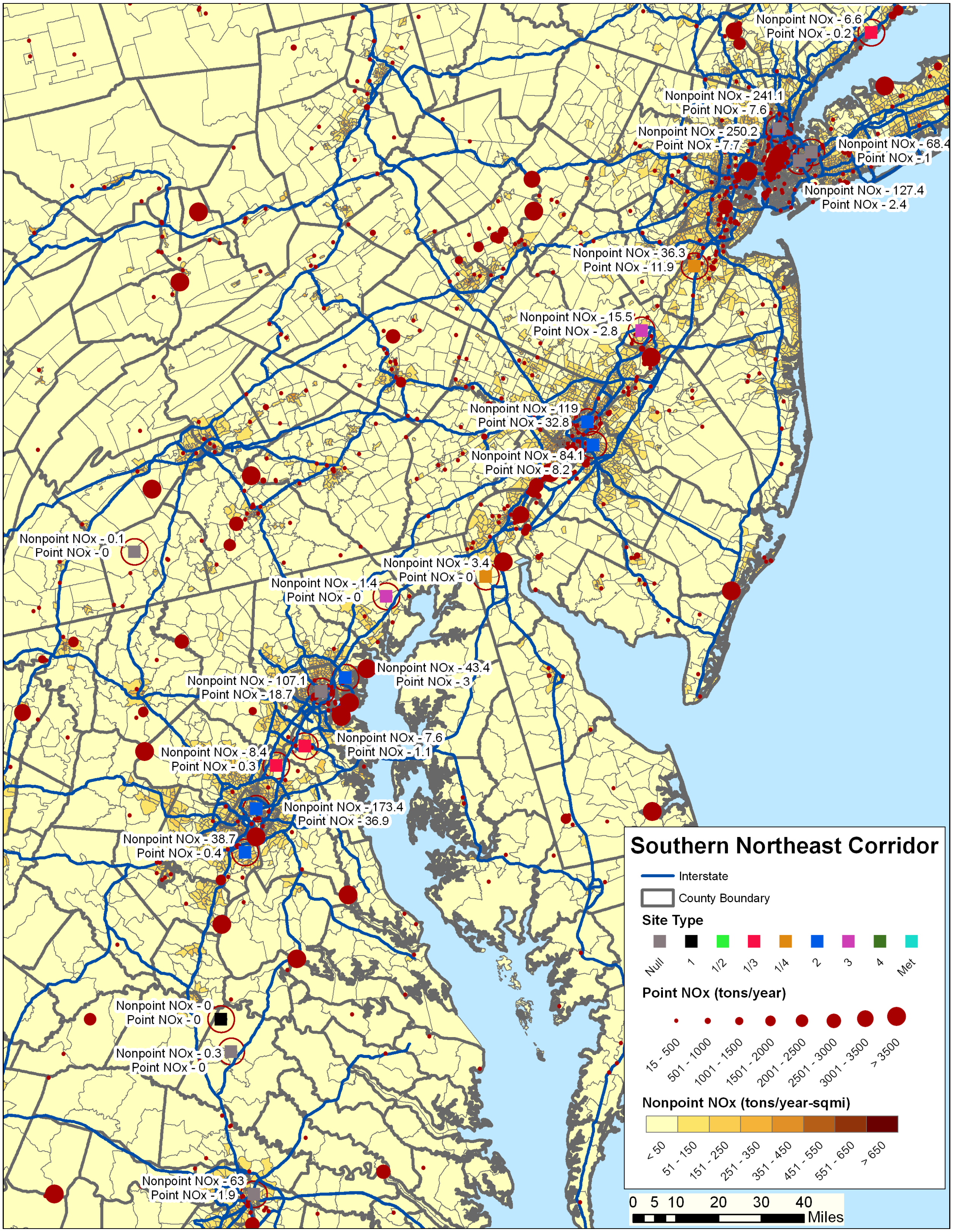

Figure 4-10. Emissions density of NO_x in Region 3 for 2002.

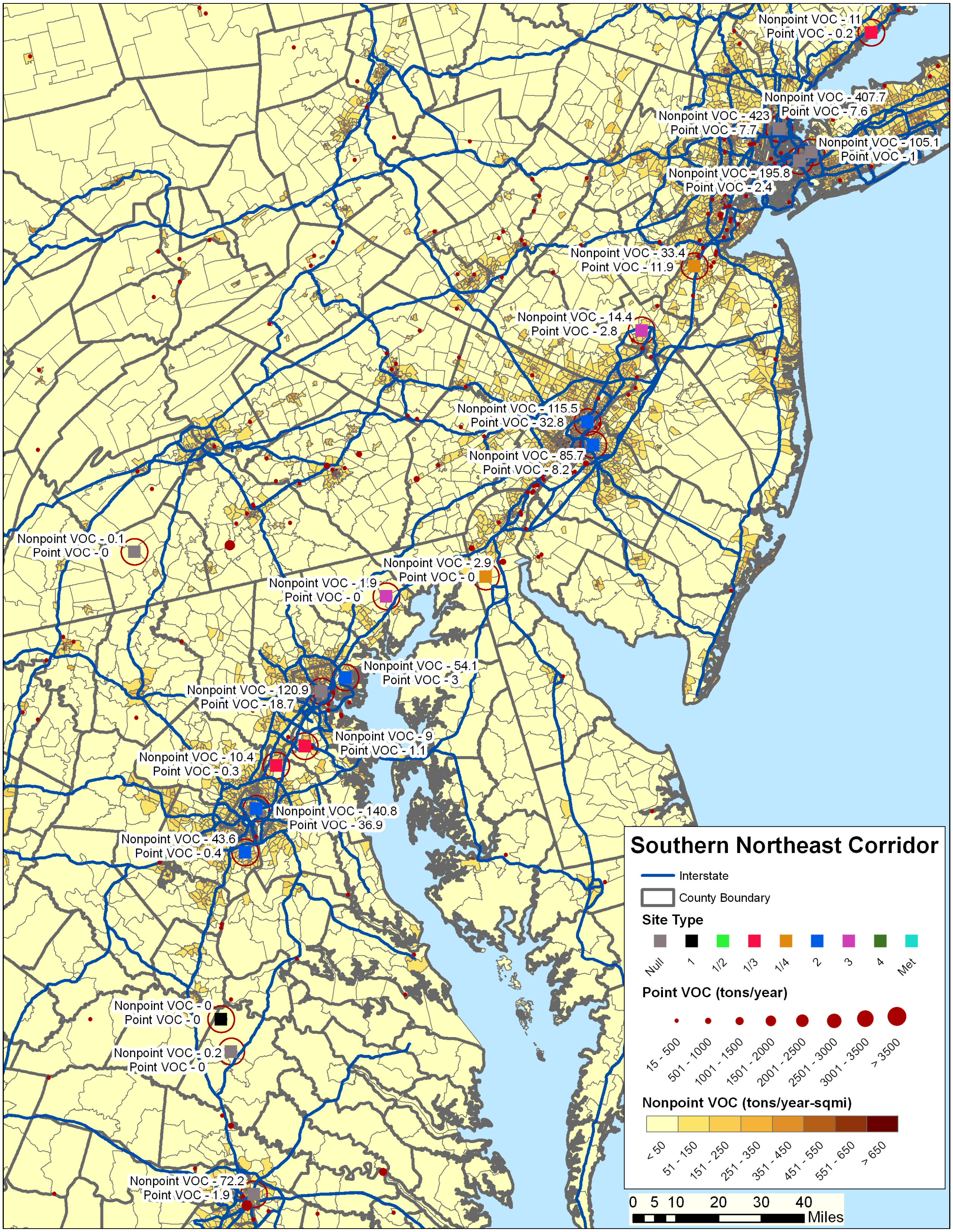

Figure 4-11. Emissions density of VOCs in Region 3 for 2002.

Table 4-3. Region 3 site-specific observations.

Type	Current Site	Analysis Comments
1	VA - Corbin	Low NO_x, high VOC concentrations (data collected during episodes of high ozone)
1/3	MD – HU-Beltsville	Not in highest ozone area; consider relocating to better meet Type 3 criteria.
	MD – Fort Meade	No NO_x measurements, not in highest ozone area; consider relocating to better meet Type 3 criteria.
2	PA – E. Lycoming	Relatively high concentrations of VOCs; consistent with Type 2 characteristics.
	DC – McMillan	Relatively low VOCs, may not represent area of highest emissions; this site is useful for analyses because of many collocated parameters; however, site may not be characteristic of a Type 2 site.
	MD – Essex	Lower precursor concentrations than the two nearby Philadelphia sites; concentrations are consistent with Type 2 site characteristics.
?	VA – Math Sci Innov.	Not clear whether this site was still operational. No NO_x.

4.3.3 Summary of Region 3 Stakeholder Discussion

Insert text here

4.3.4 Regional Recommendations

- Maximum ozone sites in this region are not necessarily capturing the areas with the highest ozone concentrations. The highest ozone concentrations in Washington DC are often south or east of the city boundaries. The highest ozone concentrations in the Philadelphia area are also far to the east. Changing the location of the Type 3 sites to capture the highest concentrations should be considered.
- Redundancy analyses should be considered within Region 3 and at the Camden site in Region 2 to determine if (1) all the current Type 2 monitors are displaying unique precursor mixes and (2) they are needed.

4.4 REGION 4 – SOUTHEAST

4.4.1 Overview

Region 4 comprises the southeastern United States. The only PAMS area in the Southeast is Atlanta. However, other nonattainment areas include Charlotte, North Carolina; Memphis, Knoxville, Nashville, and Chattanooga, Tennessee; and a few other counties in North and South Carolina. Charlotte is currently classified as a moderate nonattainment area, while

Atlanta is considered a marginal nonattainment area for ozone. Region 4 has four active monitoring sites in the Atlanta metropolitan area: one Type 1, two Type 2, and one Type 3.

4.4.2 Key Findings

- Atlanta has a marginal ozone problem under the new standard. From 2004-2006, the site with highest ozone concentrations in the region averaged 20 days of maximum 8-hr ozone concentrations above 75 ppb (**Figures 4-12 and 4-13**).
- Atlanta's precursor emission concentrations are comparable to those in the Northeast (**Figures 4-14 and 4-15**).
- The four sites in Atlanta are the only sites in the region, constituting a very sparse network in the Southeast.
- The upwind and downwind sites in Atlanta reported more than 50% of data below MDL. The reported MDLs were among the most sensitive in the nation, so it is not clear how to improve this situation.
- All the Atlanta sites have data records long enough to be suitable for trends analysis.
- The South DeKalb site is a good candidate for source apportionment analysis.
- Site-specific observations are provided in **Table 4-4**.

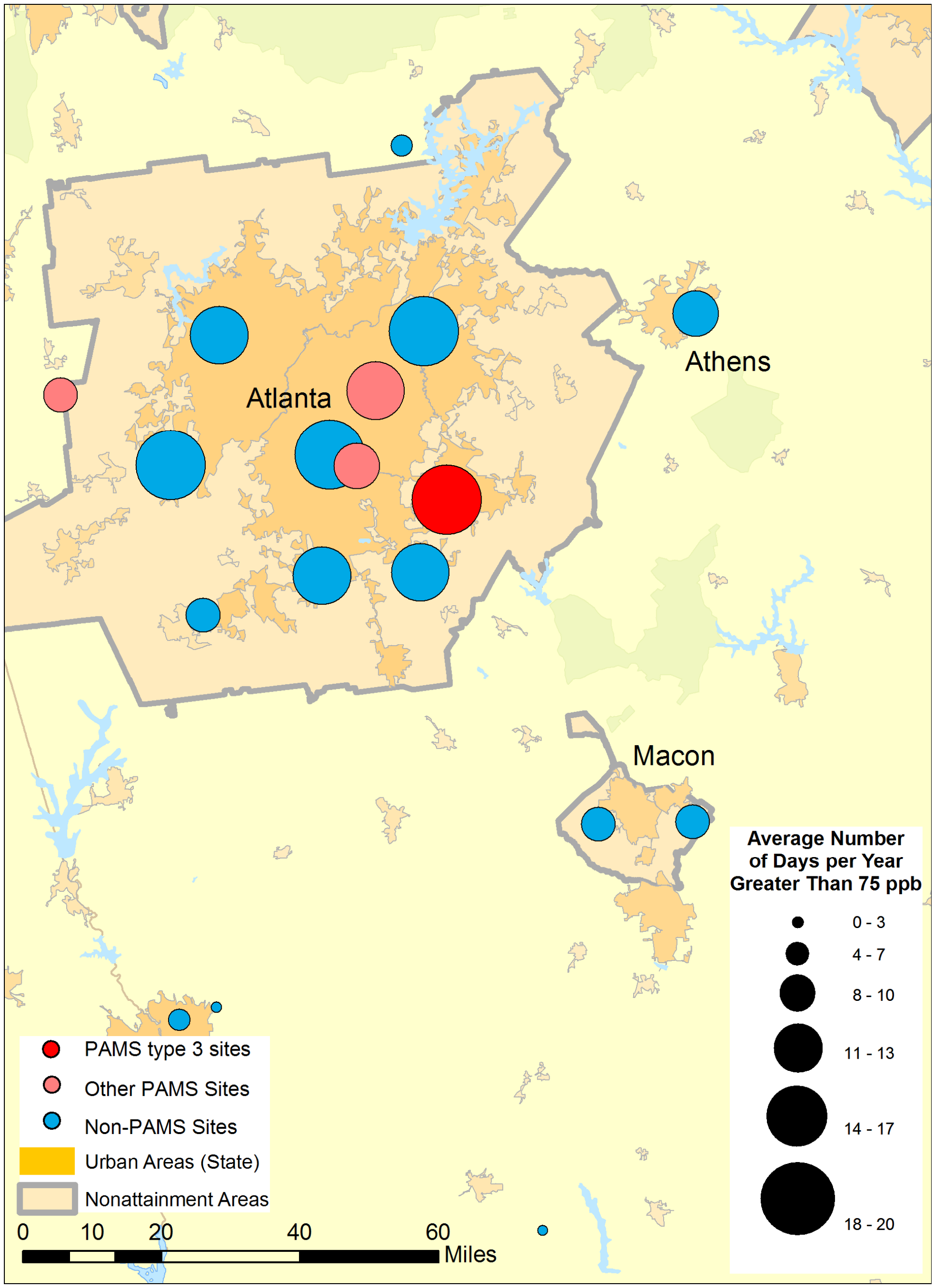

Figure 4-12. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Atlanta.

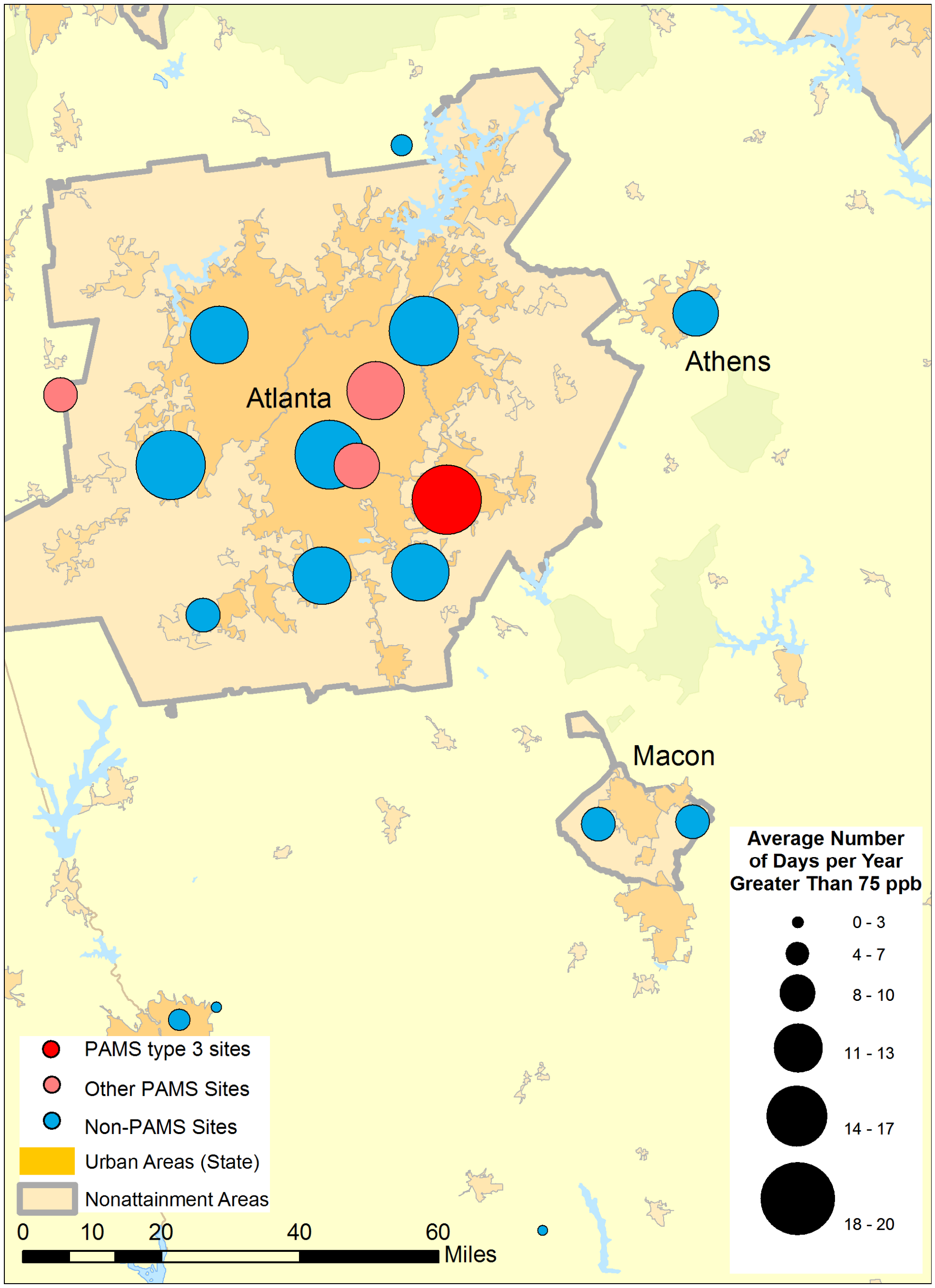

Figure 4-13. Average number of days a site experiences maximum ozone concentrations greater than 75 ppb in nonattainment areas in Atlanta.

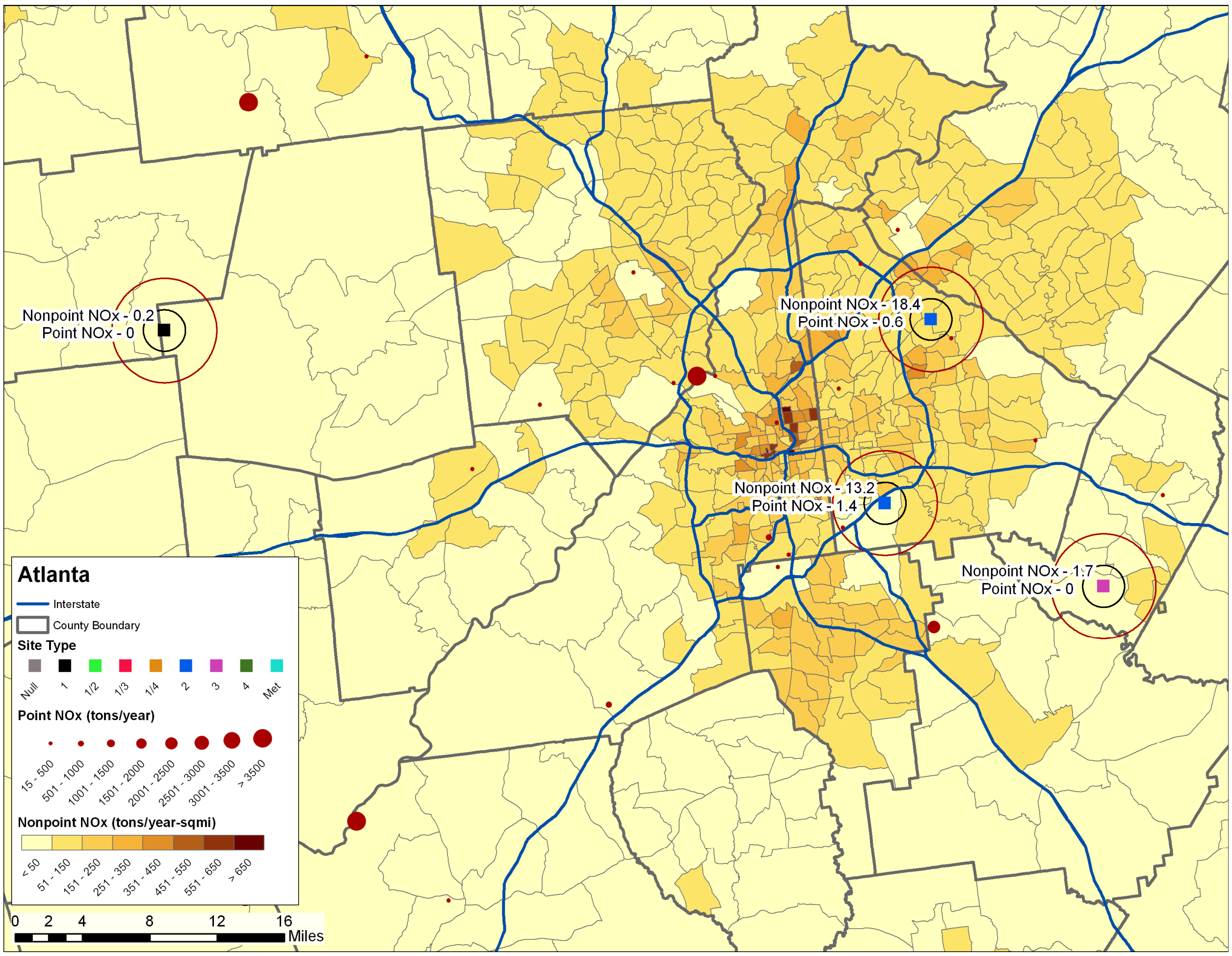

Figure 4-14. Emissions density of NO_x in Atlanta for 2002.

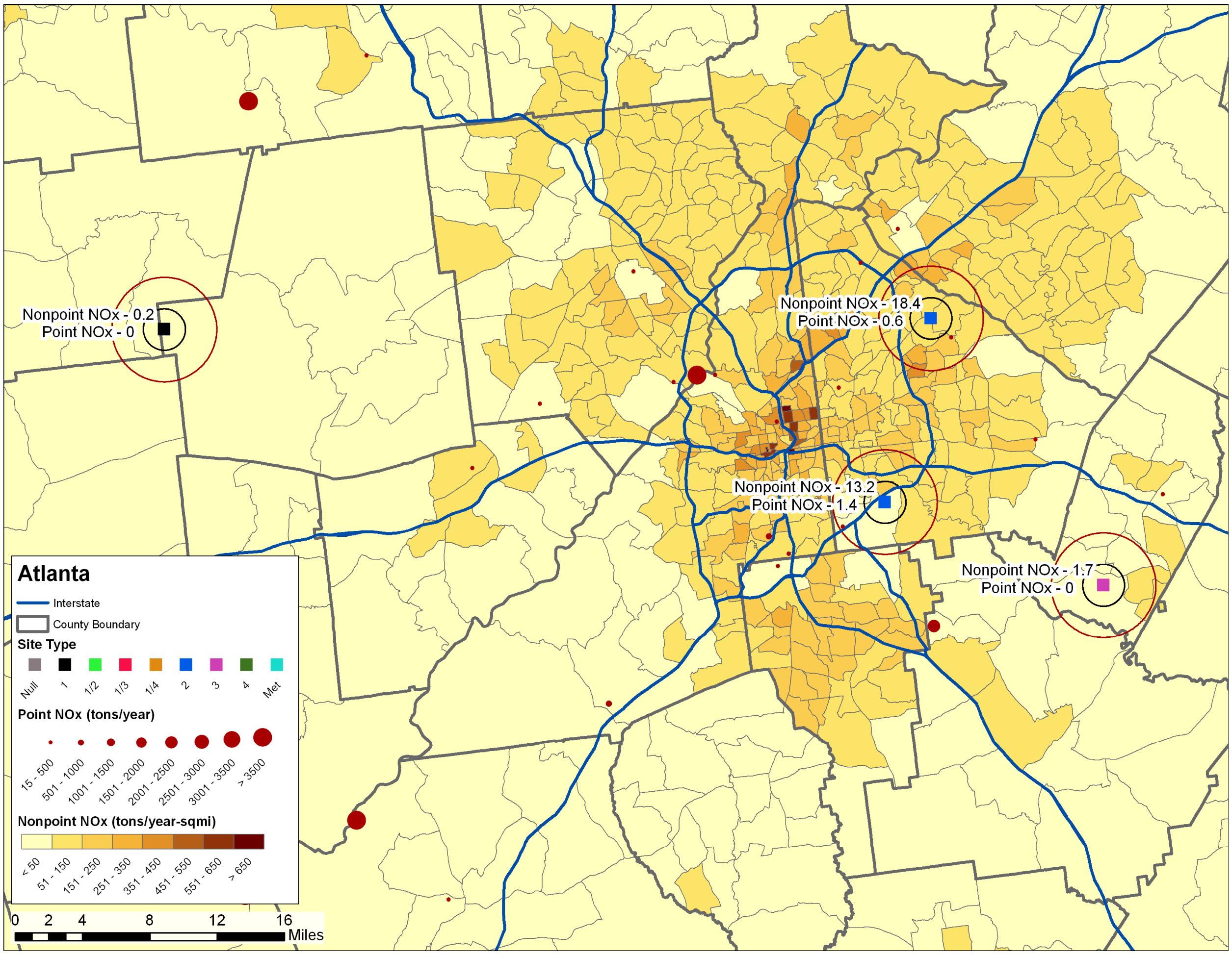

Figure 4-15. Emissions density of VOCs in Atlanta for 2002.

Table 4-4. Site-specific observations for Region 4.

Type	Current Site	Analysis Comments
1	GA – Yorkville	Low concentrations far outside the city; consistent with Type 1 site characteristics.
2	GA – Tucker	May not be close enough to highest emissions; consider relocating site.
	GA – S. DeKalb	May not be close enough to highest emissions, possible titration; consider relocating site.
3	GA – Conyers	High concentrations of ozone; consistent with Type 3 site characteristics.

4.4.3 Summary of Region 4 Stakeholder Discussion

Insert text here

4.4.4 Regional Recommendations

- The map showing average number of days per year when ozone concentrations were greater than 75 ppb map (Figure 4-12) suggests that concentrations at the southern maximum precursor site may be titrated by local emissions. While this is potentially reasonable for a Type 2 site, it may be worthwhile examining whether local NO_x sources are influencing the ozone concentrations at this site.
- Ozone concentrations are equivalently high at multiple sites in and around Atlanta, including one site between the upwind and maximum precursor emissions site. It may be worthwhile to repurpose one of the Type 2 sites as a second Type 3 site to attempt to capture the maximum ozone concentrations "upwind" of the urban core.

4.5 REGION 5 – GREAT LAKES

4.5.1 Overview

Region 5 is comprised of the Lake Michigan area. The PAMS areas in the Lake Michigan area include the Chicago area, Milwaukee, Sheboygan, and Allegan Co., MI. Most of the PAMS monitoring sites are located in the Lake Michigan nonattainment area. Region 5 has four active monitoring sites in the Lake Michigan area: three Type 2 and one Type 3.

4.5.2 Key Findings

- Chicago and Milwaukee are classified as having a moderate ozone problem by EPA. From 2004-2006, the site with the highest ozone concentrations in the Lake Michigan area (in Allegan County) averaged 13-15 days when ozone concentrations were above 75 ppb (**Figures 4-16 and 4-17**).
- The Lake Michigan area experiences precursor emission concentrations that are relatively low compared to those in other metropolitan areas (**Figures 4-18 and 4-19**). The highest precursor concentrations in the region are recorded at the Gary-IITRI site, while morning precursor concentrations at the Chicago-Jardine site were low for a maximum precursor site.
- The Lake Michigan network is sparse relative to other PAMS networks.
- The two sites located in Illinois reported poor data quality with about 58% of data below MDL. The MDLs were among the most sensitive in the nation, so it is not clear how this situation can be improved. The Wisconsin and Indiana sites had the same MDLs but a significantly higher percentage of data above the MDL.

- All the Lake Michigan sites have data records long enough to be suitable for trends analysis, although the Wisconsin site has the shortest record of the four.
- The Gary site is a good candidate for source apportionment analysis.
- Site-specific observations are listed in **Table 4-5**.

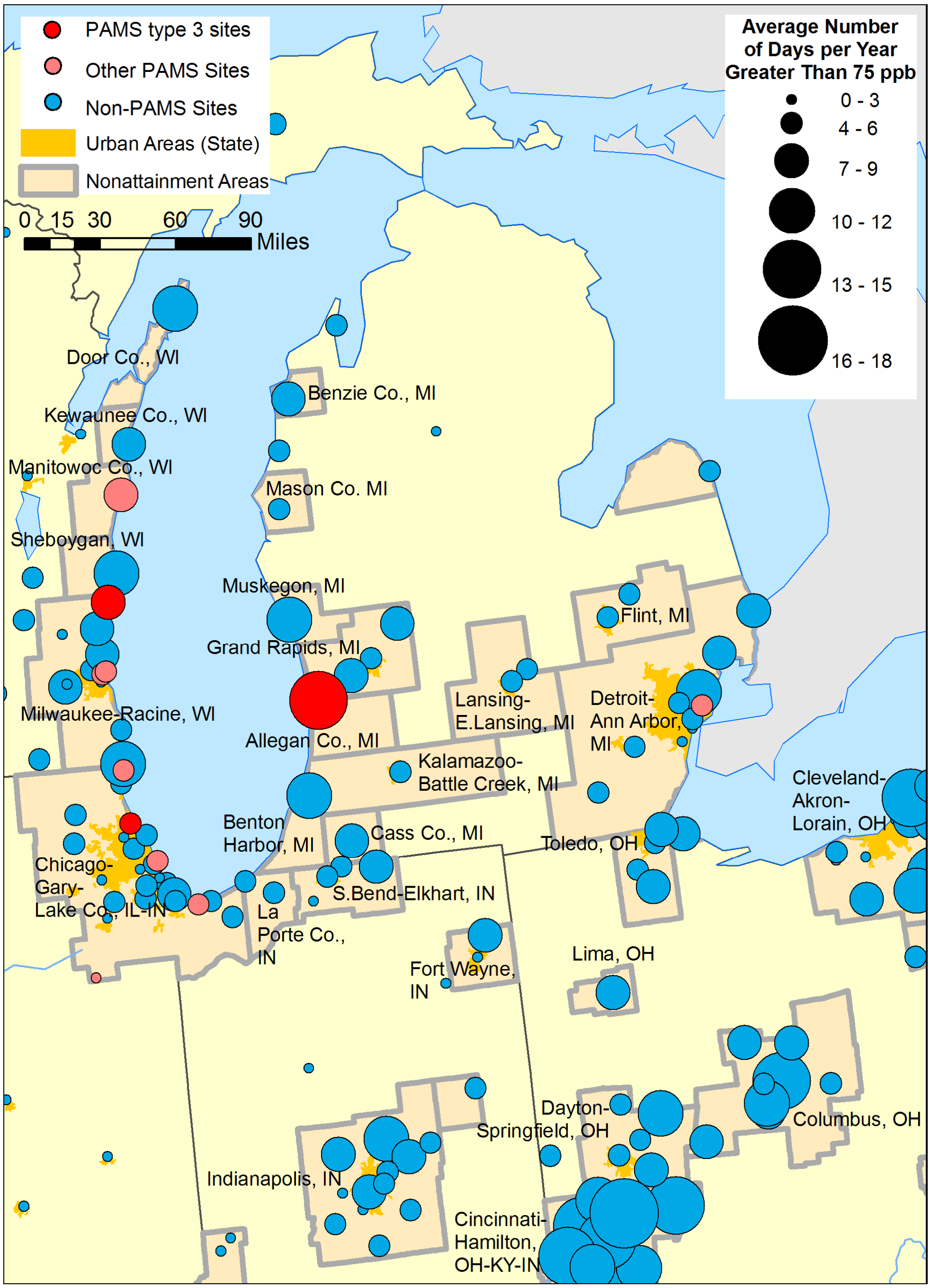

Figure 4-16. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in the Lake Michigan area.

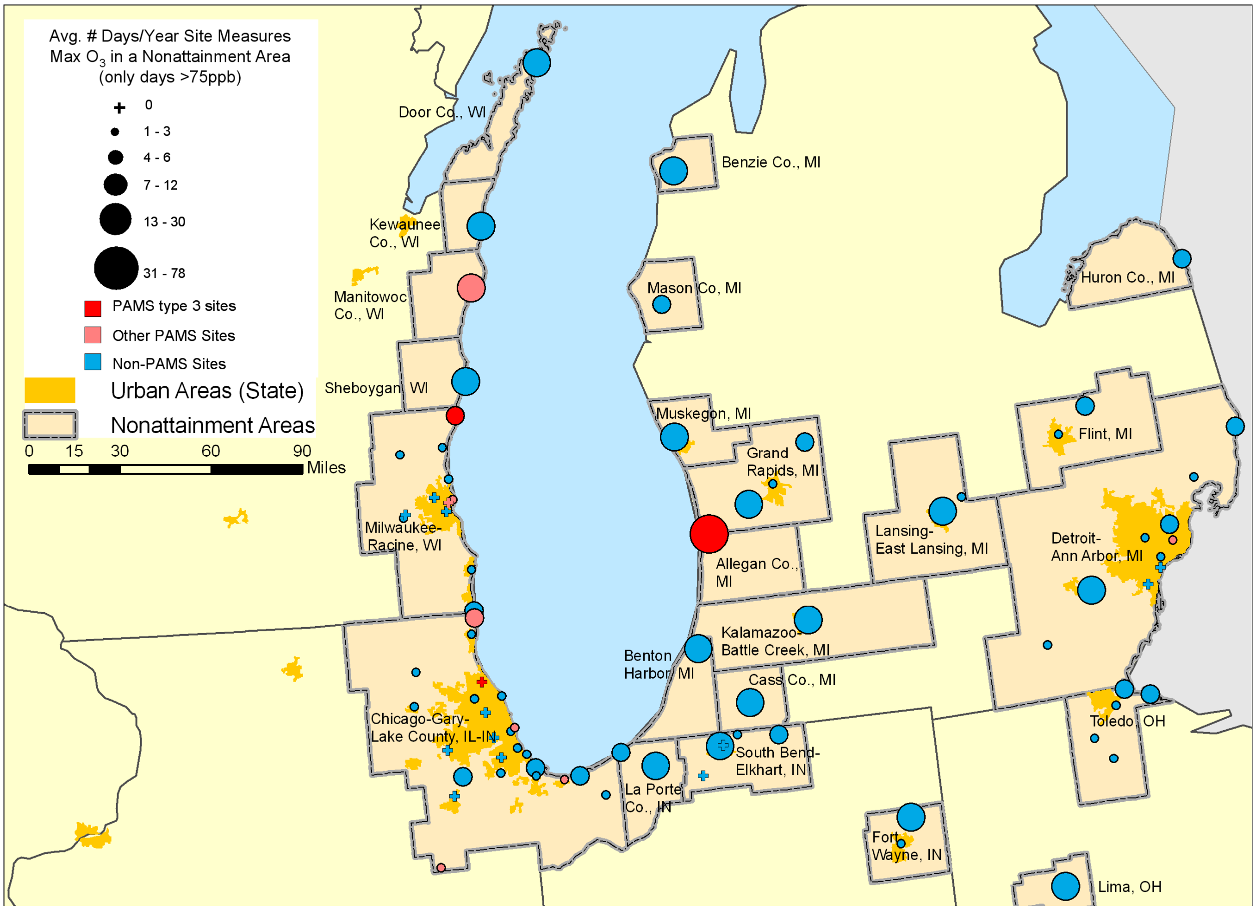

Figure 4-17. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Lake Michigan area.

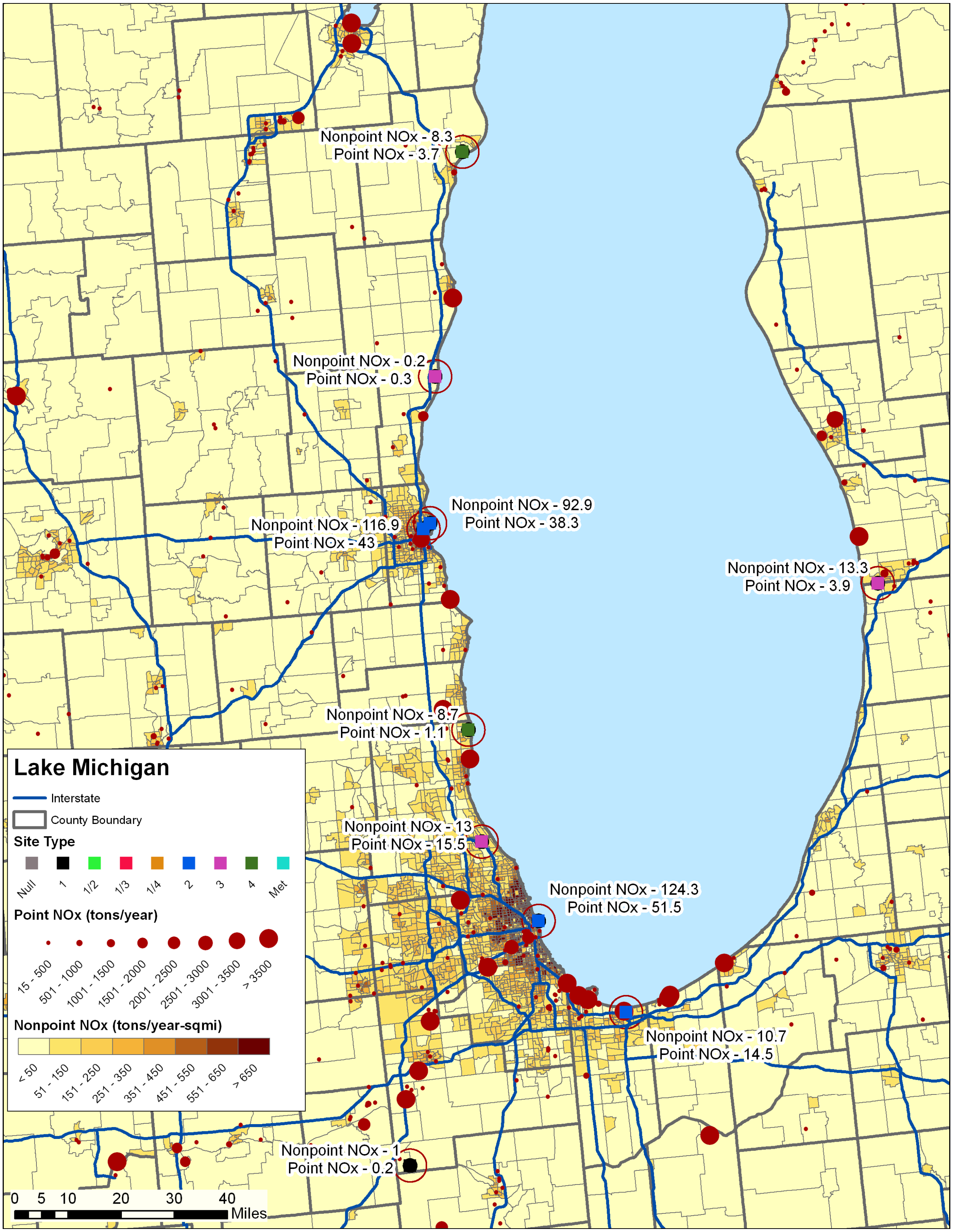

Figure 4-18. Emissions density of NO_x in Lake Michigan for 2002.

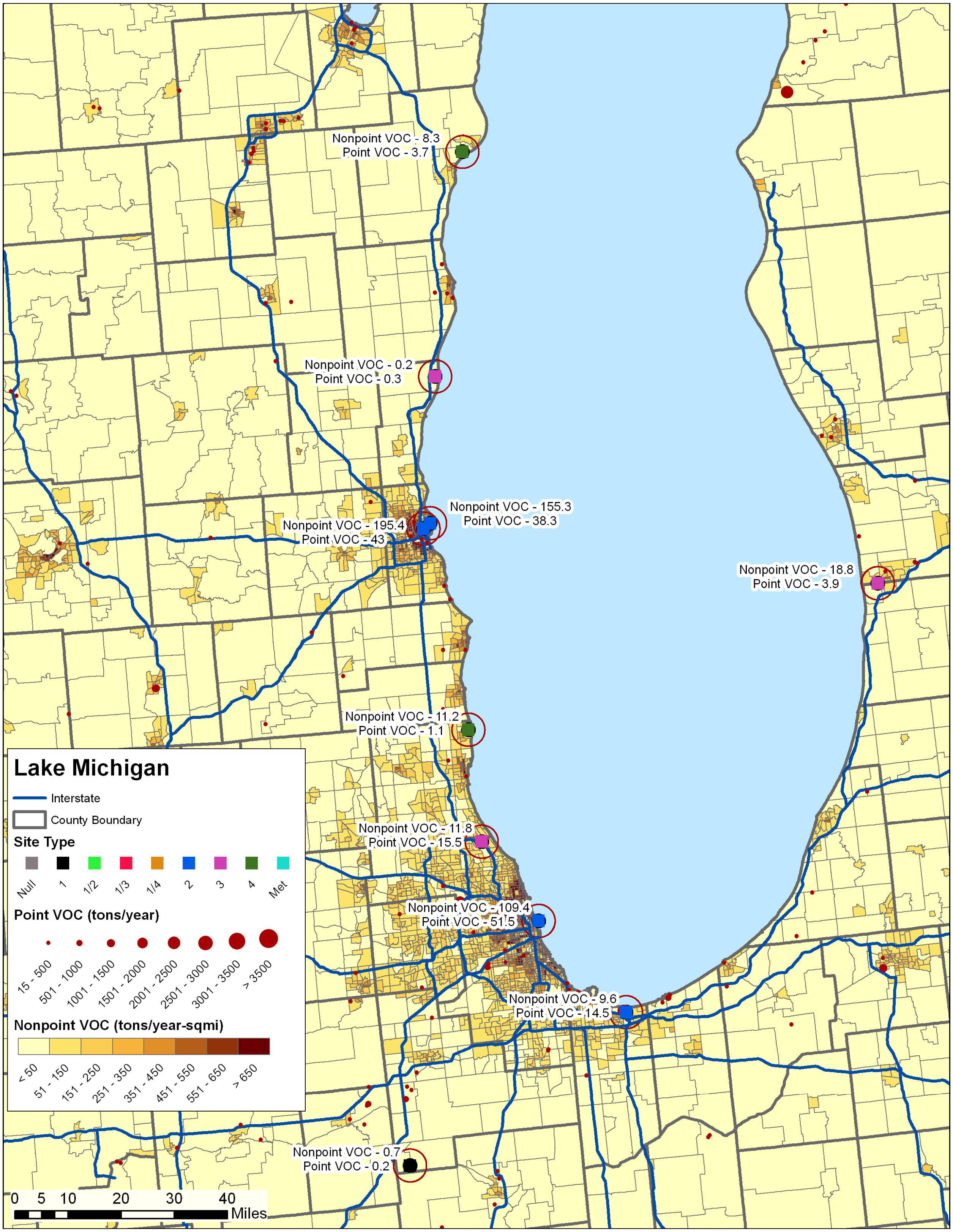

Figure 4-19. Emissions density of VOCs in Atlanta for 2002.

Table 4-5. Region 5 site-specific observations.

Type	Current Site	Analysis Comments
2	IN – Gary	May not be close enough to highest emissions; additional regional analysis needed.
	IL – Jardine	Low concentrations for a maximum precursor site; consider moving to higher emissions site.
	WI – SE Reg. HQ	Moderate concentrations; likely consistent with Type 2 site characteristics.
3	IL – Northbrook	Not adequately sited for capturing maximum ozone; data more consistent with Type 2 designation.

4.5.3 Summary of Region 5 Stakeholder Discussion

PAMS Areas

The Clean Air Act Amendments of 1990 require enhanced ozone monitoring in serious and above areas. Pursuant to EPA's ozone implementation rule for the 1997 8-hour standard (Phase I), serious areas are those with design values that are at least 33% greater than the standard. Assuming this same criteria for the new 75 ppb standard, a serious area would be one with a design value of at least 100 ppb. Based on current air quality data (2004-2006 and 2005-2007), the only areas with design values of 100 ppb (or greater) are in California (Bakersfield, Sequoia National Park, Los-Angeles – South Coast Air Basin, Los Angeles – San Bernardino Counties, and Riverside County) and Texas (Houston).

Three options are suggested for designating PAMS areas[4]:

1. Consider only areas with current design values (2004-2006 or 2005-2007) equal to or greater than 100 ppb. Note, this would result in a reduction in the national funding level for PAMS (i.e., only six PAMS areas) and a change in the regional allocation (i.e., all the PAMS money would go to California and Texas).
2. Maintain the original list of 24 PAMS areas.
3. Based on the original list of PAMS areas, determine a reasonable cut-point which would provide a balance between continuity and current air quality. A preliminary assessment indicates that a cut-point on the order of 90 ppb (20% greater than the standard) would keep the PAMS areas close to the original list and would keep about the same number of areas as the original list (requiring about the same funding level).[5]

We (Region 5 Great Lakes workgroup) recommend that EPA pursue Option 3.

Funding

[4] Beaumont-Port Arthur has PAMS sites, even though it was originally classified by EPA as moderate (not serious) nonattainment.
[5] The preliminary assessment indicates a few existing areas below the 90 ppb cut-point (e.g., Providence, Boston, Portsmouth, Beaumont-Port Arthur, El Paso, and Phoenix) and a few new areas above (e.g., Charlotte and Cleveland).

Nationally, EPA provides $14,002,502 for PAMS monitoring and data analysis. Region V receives $1,250,268 ($959,749 for monitoring and $290,519 for data analysis).

Ozone, especially in light of the new 8-hour standard, remains a pervasive problem in the eastern half of the country, and in California. The PAMS program provides valuable information to support SIP development and tracking. As such, the national funding level should be maintained or, in light of PAMS network needs (see, for example, additional program needs discussed below for the Lake Michigan area), increased.

The responses to STI's December 2007 information request and May 2008 questionnaire suggest that the current PAMS funding is not in line with the current needs. This may be because the funding is insufficient or is not being used as intended. The current regional allocations appear to be based on the number of PAMS areas. If EPA changes the PAMS areas (see comment above), then this will result in a reallocation of funds.

An alternative means of allocating funds is for each PAMS area to prepare (following revisions to the networks based on this assessment) an estimate of the cost for operating the enhanced (PAMS) measurements (above and beyond the current NAMS/SLAMS program). A looming problem with the current PAMS program is that the equipment utilized is getting old and little or no funds have been allocated to providing replacements. This is particularly true for the auto-GCs, which in some cases are over 10 years old and are no longer supported by the manufacturer (e.g., no tech support or repair parts). Also, laboratory costs for VOC analyses have continued to rise and that has eroded some of the program elements (e.g., to balance increased costs for labs it was necessary to curtail sampling for certain parameters). Consequently, cost estimates should include equipment (including replacement/upgrade of older equipment[6]), operational support (including start-up/support for new sites), personnel, and data management expenses. EPA should review the cost estimates and determine an equitable allocation for each area.

Regardless of which approach is taken, greater accountability in using PAMS funds is encouraged. More effort should be made to demonstrate that the PAMS data are being used. Each PAMS area (or group of areas) should develop data analysis plans for any continuing networks. The plans should address the regional data goals, identify how the network addresses the goals, detail data validation required for the network, and identify the data analyses to be completed using the network data. In addition, each PAMS area (or group of areas) should provide a PAMS data analysis report at least every five years (e.g., on same cycle as the regional network assessments).

Finally, funds for the management, review and analysis of monitoring data must also be included when project budgets are developed -- we recommend 20% of the total budget. We note that EPA is now requiring states to certify PAMS data. Better validation guidance and funding will be required to effectively certify all PAMS data. The funding and guidance are required, because certifying the data will require additional efforts from states.

[6] It might be worthwhile to provide a small contract to Chromium SCS (Ian Seeley) to assess existing systems and make recommendations on which systems must be replaced and which systems may be operating well enough to remain in service.

Data Analysis

What is the value of PAMS data? We believe that PAMS data are essential for tracking emissions changes (and assessing control strategy effectiveness), and supporting control strategy development (e.g., modeling and observation-based data analyses). To this end, LADCO recently conducted a cursory analysis of PAMS data focused mostly on trends in precursor concentrations. The results showed downward trends in VOC species and NO_x. Further examination of these trends should be done to determine if changes in precursor emissions (and concentrations) can explain the downward trend in ozone concentrations across the region. Also, further work is needed to establish a mechanism for using PAMS data to track expected changes in precursor concentrations due to new control programs.

In addition, LADCO has previously used PAMS data to evaluate emissions inventories (e.g., ambient:emissions ratio comparisons[7]), support modeling (e.g., evaluate model performance), and determine control preferences (e.g., identify VOC- v. NO_x-limited conditions using MAPPER).

Region V Recommendations

The current PAMS network for the Lake Michigan area meets the minimum requirements of the October 17, 2006 revisions to the Ambient Air Monitoring Regulations. Nevertheless, in light of the analyses performed by STI to support the PAMS Network Assessment, several changes to the Lake Michigan regional network are suggested:

Type	Current Site	Suggested Changes	Proposed Site
1	IL – Braidwood	(none)	IL - Braidwood
2	IL – Jardine	Revise: establish primary site	IL - Northbrook
		Classify Northbrook as secondary Type 2 site	IL - Mayfair (???)
	IN – Gary	(none)	IN - Gary
	WI – Milwaukee	(none)	WI - Milwaukee
3	IL – Northbrook	Reclassify as secondary Type 2 site	
	WI – Harr Beach	Revise: use another site	WI - Sheboygan
	MI – Holland	(none – but need NO_x/NO_y)	MI - Holland
4	IL – Zion	Revise: use another site (and classify as Type 3)	WI – Chiwaukee
	WI – Manitowoc	Revise: use another site	WI – Newport Beach

The resource implications of these changes are as follows:

VOC Sampling - The costs associated with VOCs via auto-GC or laboratory analysis are quite high and consume a big piece of the PAMS budget. Alternate programs should be considered. California uses a Total Hydrocarbon (THC) measurement as a surrogate for speciated VOC sampling. (Another option is episodic sampling for VOCs, which worked well during the Lake Michigan Ozone Study, as we were able to focus sampling on days when ozone levels were the highest.) If THC measurements are determined to be appropriate

[7] An updated ambient:emissions ratio comparison will be performed using 2005 data.

(and a reasonable sampling frequency can be defined), then sufficient resources should be provided to establish these measurements at PAMS sites. Even so, speciated VOC measurements are needed at the Chicago, Gary, and Milwaukee Type 2 sites.

IL – Need to provide sufficient resources to get VOC (new auto-GC) and NO_x at new primary Type 2 site. IL estimates that new site startup costs, new equipment (including new auto-GC), and additional personnel costs for the first year cost would be $260,000. There would also be some costs for equipment replacement at Northbrook (e.g., THC[8] and NO_y). Northbrook is to be a NCORE site and needs some reinvestment. (Note, de-classifying or even shutting down the Jardine and Zion sites will not save enough resources to pay for the new monitoring equipment.)

IN - (none, status quo)

MI - Need to provide sufficient resources to get NO_x/NO_y at Holland.

WI – Need to provide sufficient resources to move NO_x/NO_y from Manitowoc to either Chiwaukee (preferred), Sheboygan, or Newport Beach

4.5.4 Regional Recommendations

- The days when concentrations were above 75 ppb and ozone maxima maps indicate that the highest ozone concentrations are not being captured in Lake Michigan with monitors that measure the suite of PAMS hydrocarbons. If these types of measurements are important for model boundary conditions or validation, moving a hydrocarbon monitor to the eastern side of Lake Michigan may be useful.
- The sites in Chicago do not appear to meet their monitoring objectives. Relocating or repurposing these sites may help to better capture emissions from Chicago proper.
- Concentrations in Chicago were very low, but the upwind monitors do not have speciated hydrocarbon concentrations to characterize upwind concentrations. The question remains that the three Type 2 sites and the one Type 3 site (which appears to be poorly located) may not be adequate for determining modeled hydrocarbon boundary concentrations? Redundancy analysis among the Type 2 and 3 sites may indicate that one of them could be repurposed to capture concentrations outside the urbanized areas.

4.6 REGION 6 – SOUTHERN MIDWEST

4.6.1 Overview

Region 6 comprises Texas and Louisiana and other parts of the southern mid-west. The PAMS areas in Region 6 are Dallas, Houston, Beaumont, and El Paso, and Baton Rouge. Houston and Dallas are classified as moderate nonattainment areas while Baton Rouge and Beaumont are classified as marginal areas. El Paso is a special case because of its proximity to

[8] Given the age of the existing auto-GC at Northbrook and its reclassification as a secondary Type 2 site, investment in continuous speciated VOC data at this location is a lower priority.

the border. Region 6 has approximately 16 active precursor monitoring sites: two Type 1, nine Type 2, two Type 3, and three Type 1/3.

When reviewing the analysis results for Texas, a data processing issue was discovered related to how the AQS data were post-processed for this project. There are nine sites in Texas that report data to AQS in units of ppmC rather than ppbC. This is because in the 1990s when the PAMS network was established, Texas had very high hydrocarbon concentrations. A data processing error resulted in truncation of these data (retention of three significant figures rather than five) prior to performing the network assessment analyses. A thorough review of the analysis results for all other areas confirmed that this was only an issue with the data for the nine sites in Texas. While the data processing error did have an impact on the findings and recommendations from the MDL analysis, it did not impact the overall results and recommendations for the other analyses performed. The results and recommendations of the MDL analysis have been revised as appropriate.

4.6.2 Key Findings

- Dallas averaged 32-34 days when ozone concentrations were above 75 ppb from 2004-2006; Houston, 25-30 days; Beaumont, 17-23 days; Baton Rouge, 16-18 days; and El Paso, 6 days (**Figures 4-20 through 4-22**).
- Region 6 sites reported the highest average VOC precursor concentrations in the entire nation (**Figures 4-23 and 4-24**). Concentrations at NO_x sites were not as elevated relative to the rest of the country.
- The monitoring network around Houston and Beaumont is relatively dense while El Paso's network is the least dense in the nation.
- The data quality from non-Type 2 sites in Texas appears to be an issue, particularly in the Dallas area. Many of the region's sites reported more than 50% of data below the MDL. Moreover, the MDLs are among the highest in the nation. More sensitive measurements may be appropriate for the non-Type 2 sites as concentrations of hydrocarbons continue to decrease.
- Most sites in Region 6 have data records long enough to be suitable for trends analysis with the notable exception of all sites in Beaumont.
- The Hinton site in Dallas, Chamizal site in El Paso, and Deer Park and Channelview sites in Houston may all be good source apportionment candidates.
- Site-specific observations are provided in **Table 4-6**. Additionally, some sites may not be meeting the criterion for their site type, as follows:
  - <u>Type 1</u>. Concentrations of VOCs and NO_x were high at all Type 1 designated sites. These concentrations were not necessarily as high as those observed at the maximum precursor sites, but were high in an absolute concentration level relative to the rest of the country. Emissions maps suggest that some of these areas may have relatively high emissions, although the emission inventory methodology was relatively crude.
  - <u>Type 2</u>. Several of the Type 2 sites in Texas report data to AQS in ppmC because of very high concentrations in the first few years of operation; all other sites in the

PAMS network report data solely in ppbC. A data processing error resulted in truncation of these data prior to performing the concentration analysis. Therefore, the results of the concentration analysis at these sites is uncertain. However, the relative results from this analysis are still correct – high versus low concentration sites are properly identified.

– Type 3. Houston's Type 3 site recorded some of the lowest ozone concentrations in the area. The highest ozone concentrations were usually on the south side of the city. The sites north and east of the maximum ozone site in Dallas also capture higher average ozone concentrations. Baton Rouge sites appear to be misaligned to capture maximum ozone concentrations, as the Northwest-Southeast corridor experiences far higher ozone concentrations than the current Southwest-Northeast corridor. The El Paso sites are all essentially equivalent, although NO_x concentrations were relatively high for a Type 3 site.

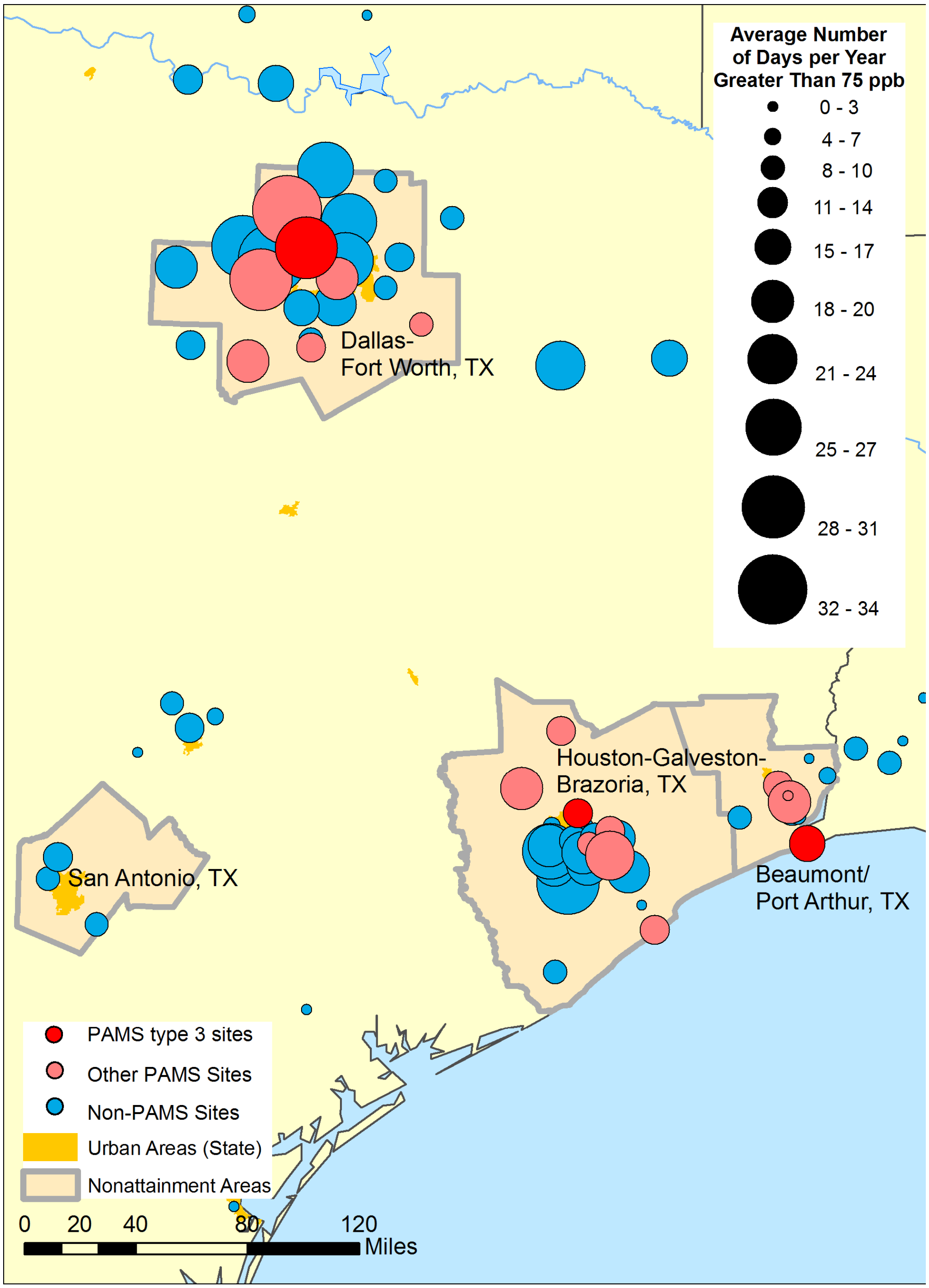

Figure 4-20. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in the East Texas area.

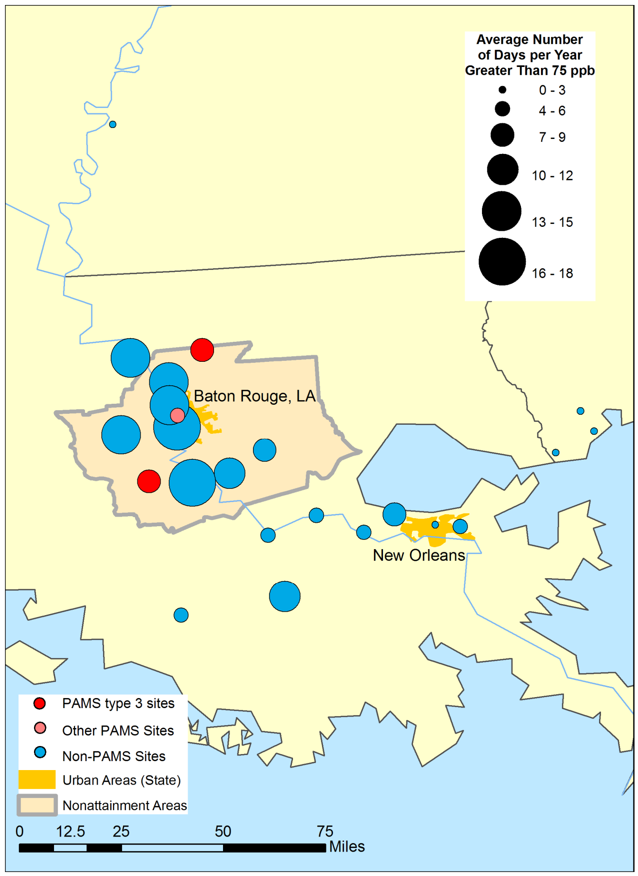

Figure 4-21. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Baton Rouge.

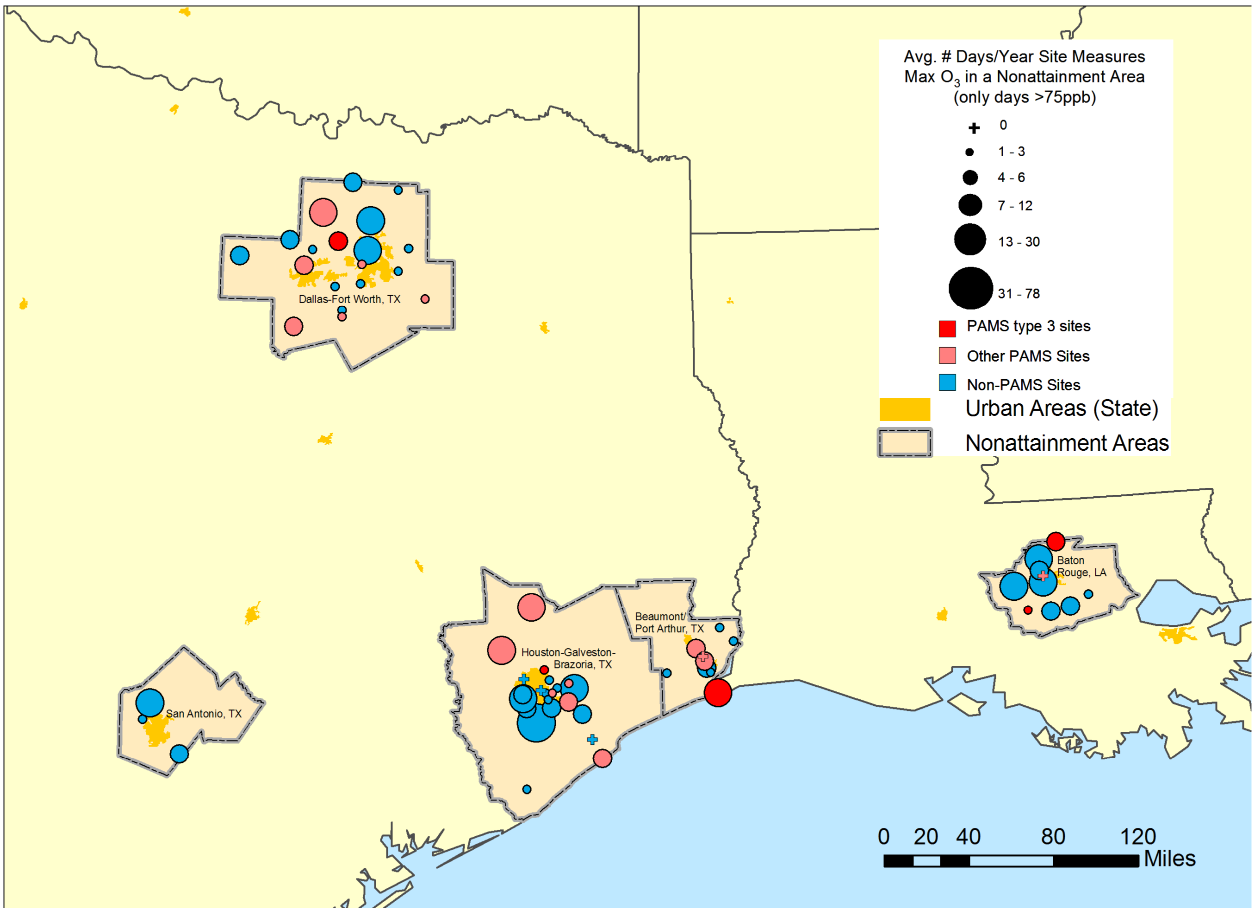

Figure 4-22. Average number of days at a site when maximum ozone concentrations were greater than 75 ppb in nonattainment areas of East Texas and Louisiana.

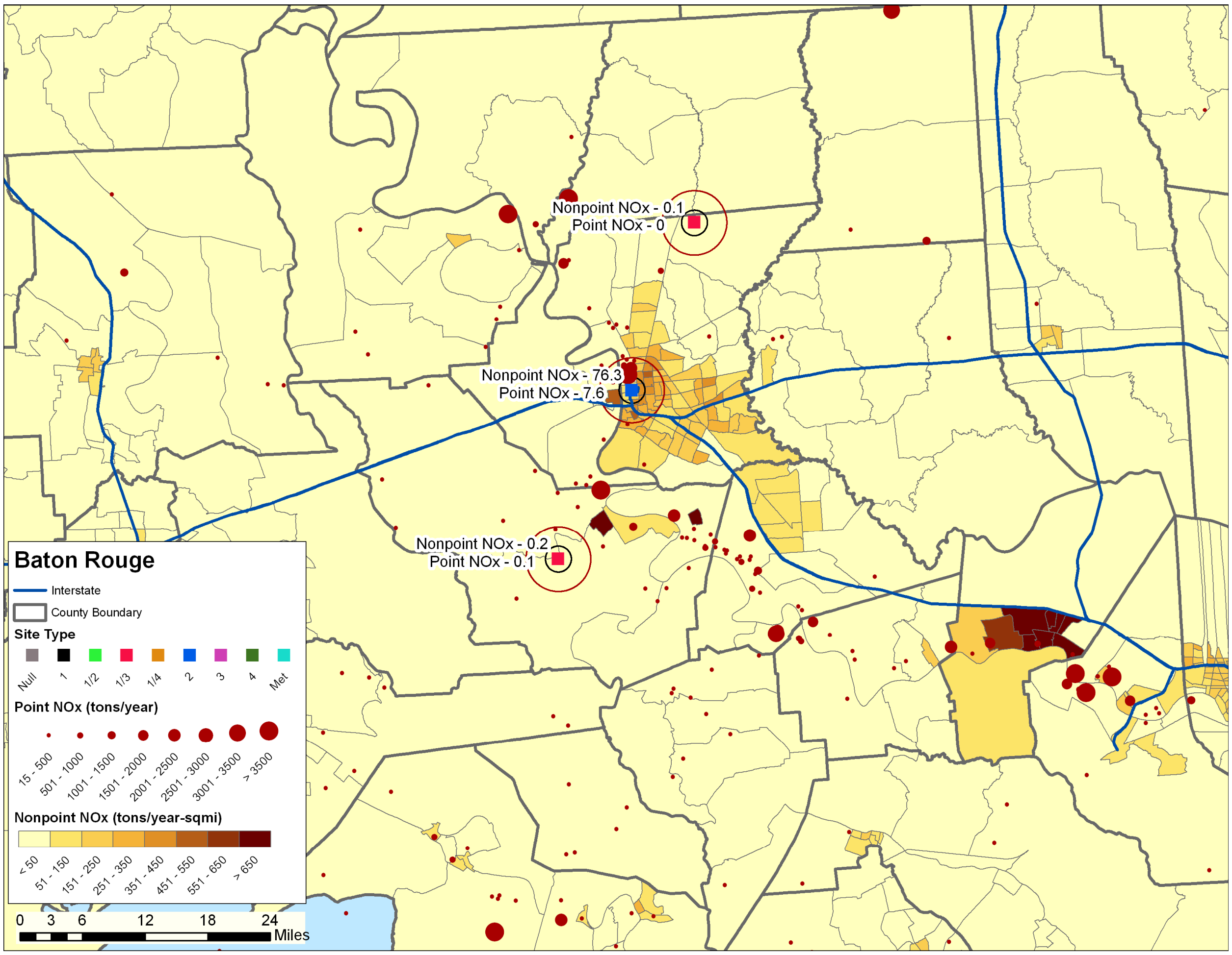

Figure 4-23. Emissions density of NO_x in Baton Rouge for 2002.

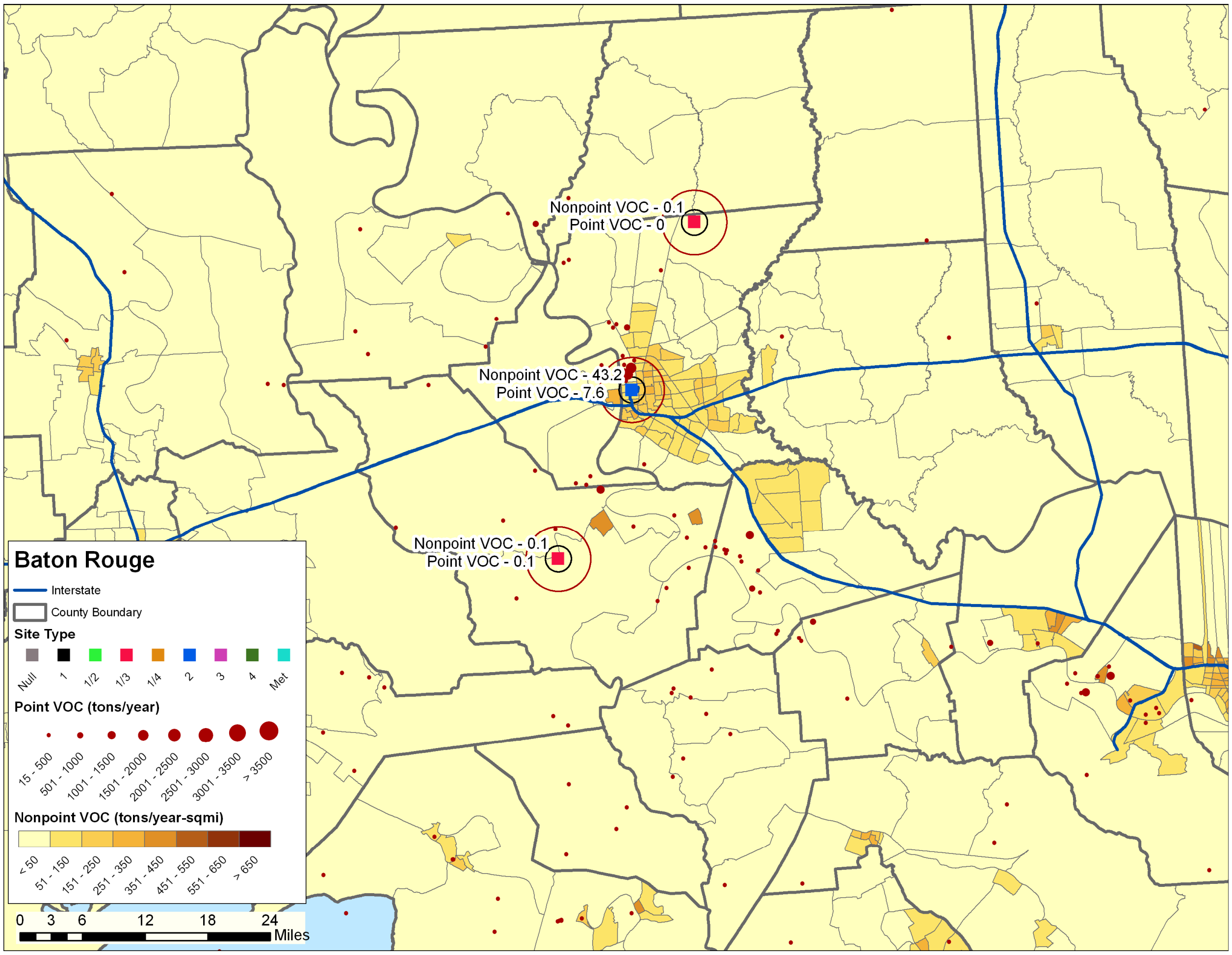

Figure 4-24. Emissions density of VOCs in Baton Rouge for 2002.

Table 4-6. Region 6 site-specific observations.

Page 1 of 2

Type	Current Site	Analysis Comments
1	TX – Ascarte Park	Highest local concentrations of VOCs and NO_x; likely inconsistent with Type 1 site characteristics.
	TX – Kaufman	High VOC concentrations; likely inconsistent with Type 1 site characteristics.
2	TX – Chamizal	Low NO_x concentrations relative to other sites in El Paso; inconsistent with Type 2 site characteristics.
	TX – Hinton	Moderate concentrations; likely consistent with Type 2 site characteristics.
	TX – Meacham	Low NO_x concentrations; inconsistent with Type 2 site characteristics.
	TX – Clinton Dr.	High VOC concentrations; consistent with Type 2 site characteristics.

Table 4-6. Region 6 site-specific observations.

Page 2 of 2

Type	Current Site	Analysis Comments
2 (con't)	TX – Channelview	High VOC, low NO_x ; consistent with Type 2 site characteristics.
	TX – Deer Park	Lowest Type 2 Houston VOC site, low NO_x consider evaluating the usefulness of the site.
	LA – Capitol	High VOC, Low NO_x consistent with Type 2 site characteristics.
	TX – Lamar	High VOC, Low NO_x ; consistent with Type 2 site characteristics.
	TX – Nederland	High VOC, Low NO_x consistent with Type 2 site characteristics.
3	TX – UTEP	Equivalently high VOCs and NO_x; may not be capturing peak ozone concentrations. Site appears to be inconsistent with Type 3 site characteristics.
	TX – Grapevine	Not capturing peak ozone concentrations; inconsistent with Type 3 site characteristics.
1/3	TX – Aldine	Not capturing peak ozone concentrations; inconsistent with Type 3 site characteristics.
	LA – Bayou Plaq.	Not capturing peak ozone concentrations; inconsistent with Type 3 site characteristics.
	LA – New Pride	Not capturing peak ozone concentrations; inconsistent with Type 3 site characteristics.
4	TX – Denton Airport	No hydrocarbons, but maximum ozone site for Dallas; consider reclassifying site as Type 3.
	TX – Tomball	No hydrocarbons, among higher ozone sites in Houston; consider reclassifying site as Type 3.
N/A	TX – Galveston	Very high morning VOCs for "upwind" site; may not be consistent with Type 1 site characteristics.

4.6.3 Summary of Region 6 Stakeholder Discussion

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4.6.4 Regional Recommendations

Many sites in Region 6 may no longer be appropriately located to meet monitoring objectives. Upwind and downwind sites often report VOC concentrations that are approximately the same as those at maximum precursor sites, while the maximum ozone concentrations are not being captured by the PAMS networks in Houston, Dallas, or Baton Rouge. A sophisticated emission inventory analysis using up-to-date data for these areas may be appropriate to determine how to rectify these discrepancies. Another option may be to use special study monitoring data from the Texas Air Quality Study (TexAQS) or other studies to examine the question of spatial variations in hydrocarbon concentrations in these areas.

- Type 1 and Type 3 sites may need to be placed farther away from the metropolitan areas to better capture upwind and maximum ozone concentrations.

- Data quality at non-Type 2 sites can be improved across the region. Lower MDLs are achievable and may make the monitoring data more useful for analysis efforts.
- Baton Rouge needs to shift its monitoring because it is missing high ozone concentrations with its current monitoring placement.

4.7 REGION 9 – PACIFIC SOUTHWEST

4.7.1 Overview

Region 9 is comprised of California, Nevada, Arizona, and Hawaii. PAMS areas include the South Coast (Los Angeles/Riverside), San Joaquin Valley (SJV), Sacramento, Phoenix, and San Diego. This region has the most severe ozone areas and has the highest and most frequent number of ozone exceedances in the nation. Region 9 has approximately 21 active monitoring sites: two Type 1, nine Type 2, four Type 3, one Type 1/2, one Type 1/3, and one Type 1/4.

4.7.2 Key Findings

- The SoCAB has the most severe ozone nonattainment classification, while the SJV and Sacramento are both classified as serious (**Figures 4-25 through 4-28**). The SJV experienced over 100 days when ozone concentrations were above 75 ppb, while the SoCAB reported over 90 days. Sacramento experienced over 40 days when ozone concentrations were above 75 ppb.
- The SoCAB and SJV areas report some of the highest precursor emission concentrations in the United States (**Figures 4-29 through 4-32**).
- The monitoring network in California is relatively dense with the SoCAB having the densest monitoring network in the nation. San Diego is also relatively dense due to its proximity to the SoCAB. The SJV and Sacramento have moderately low monitoring density in comparison. Phoenix has the second lowest monitoring density in the nation.
- The data quality in the region is poor, especially in the SJV. MDLs throughout the region are high. Despite high concentrations, more than 50% of measurements are reported below MDL at five monitoring sites in California, and most of those sites are in the SJV.
- Many sites in the region are suitable for trends analysis. Only Arizona has insufficient data to perform long-term trend analysis.
- The El Cajon and Simi Valley monitoring sites in San Diego and Ventura County have the highest number of measurements and may be good candidates for source apportionment.
- Sites are generally not far enough downwind to capture highest ozone concentrations. Site-specific observations are provided in **Table 4-7**.

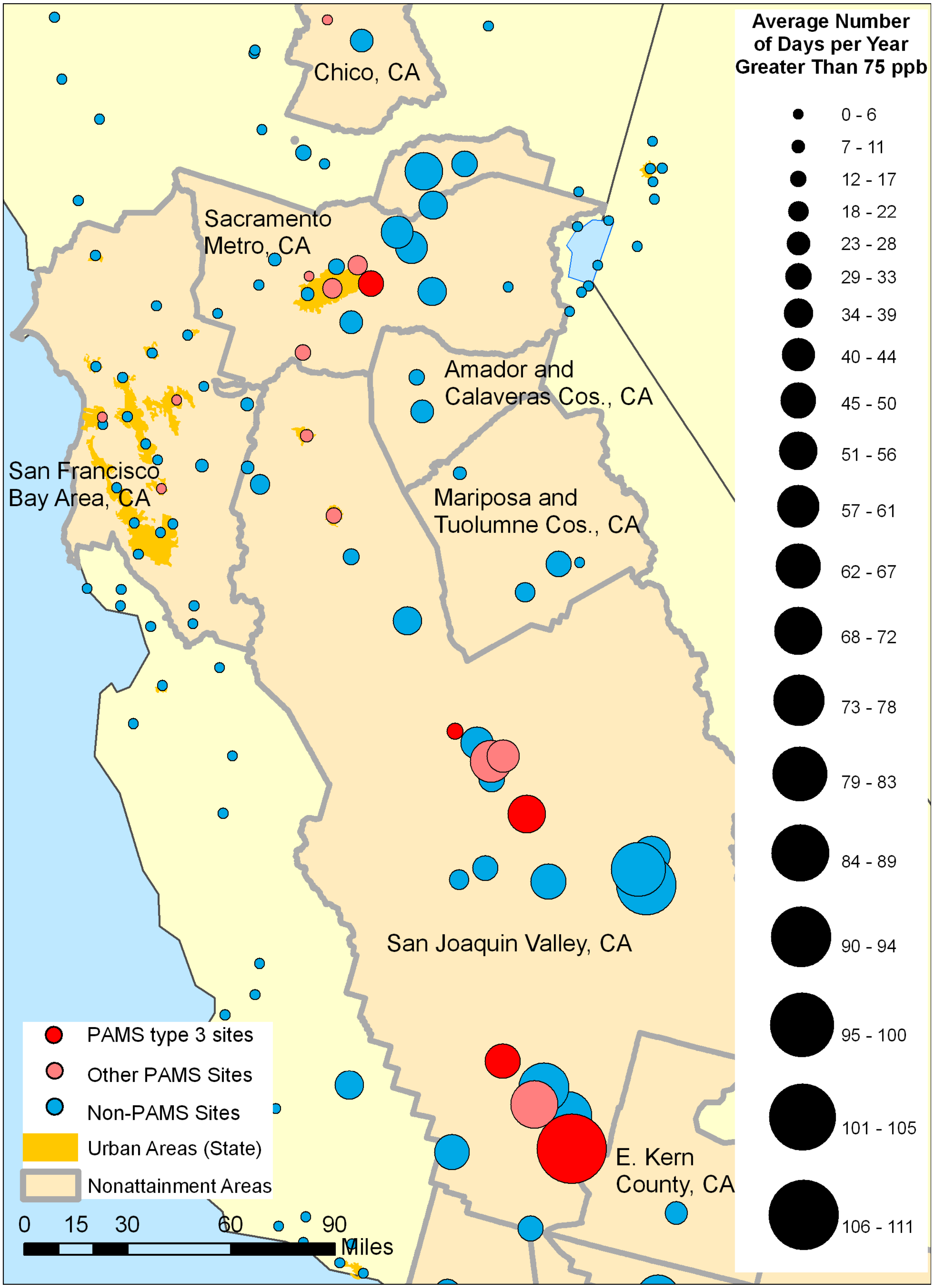

Figure 4-25. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Central California.

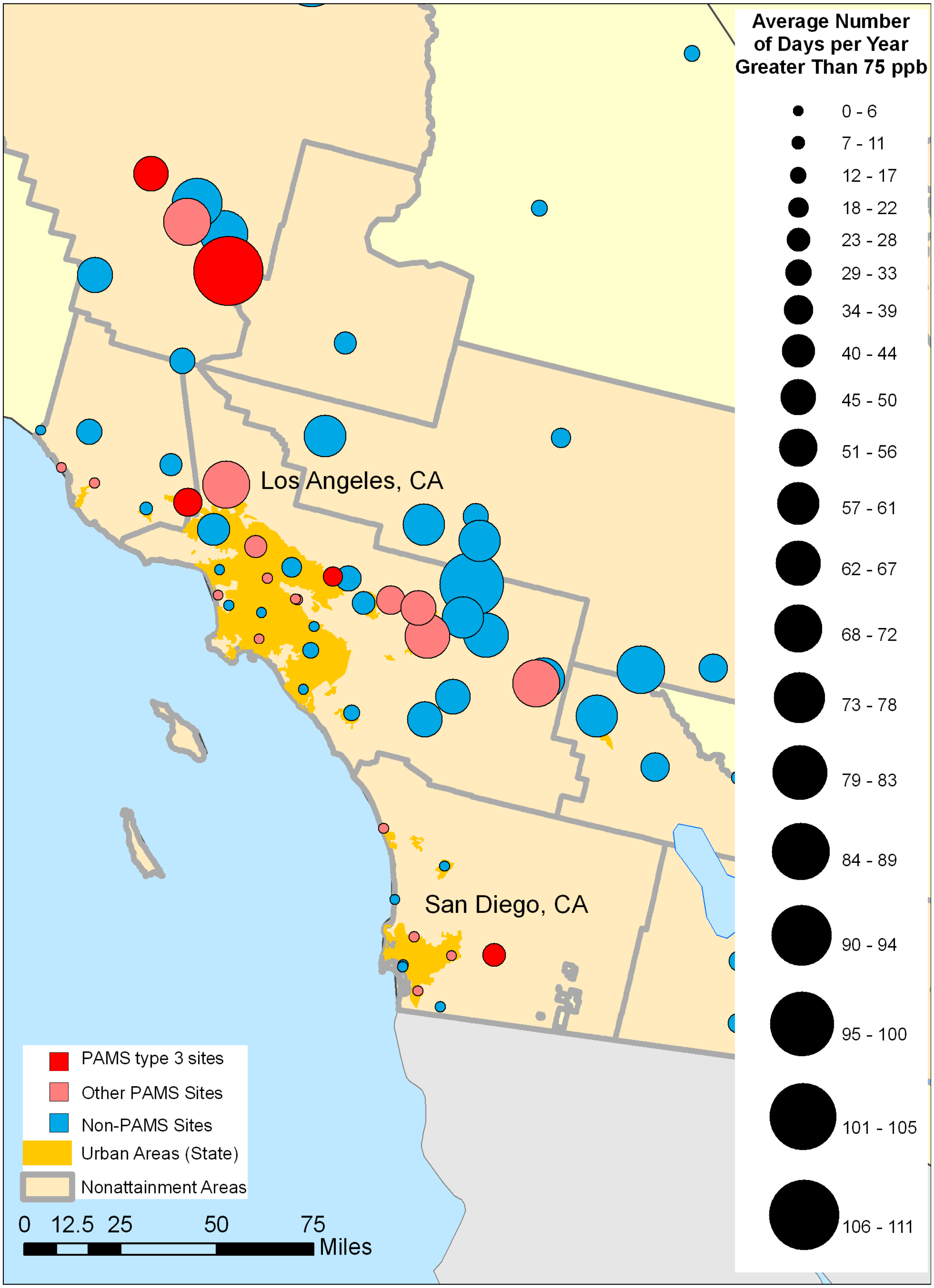

Figure 4-26. Average number of days per year when ozone concentrations were greater than 75 ppb from 2004-2006 in Southern California.

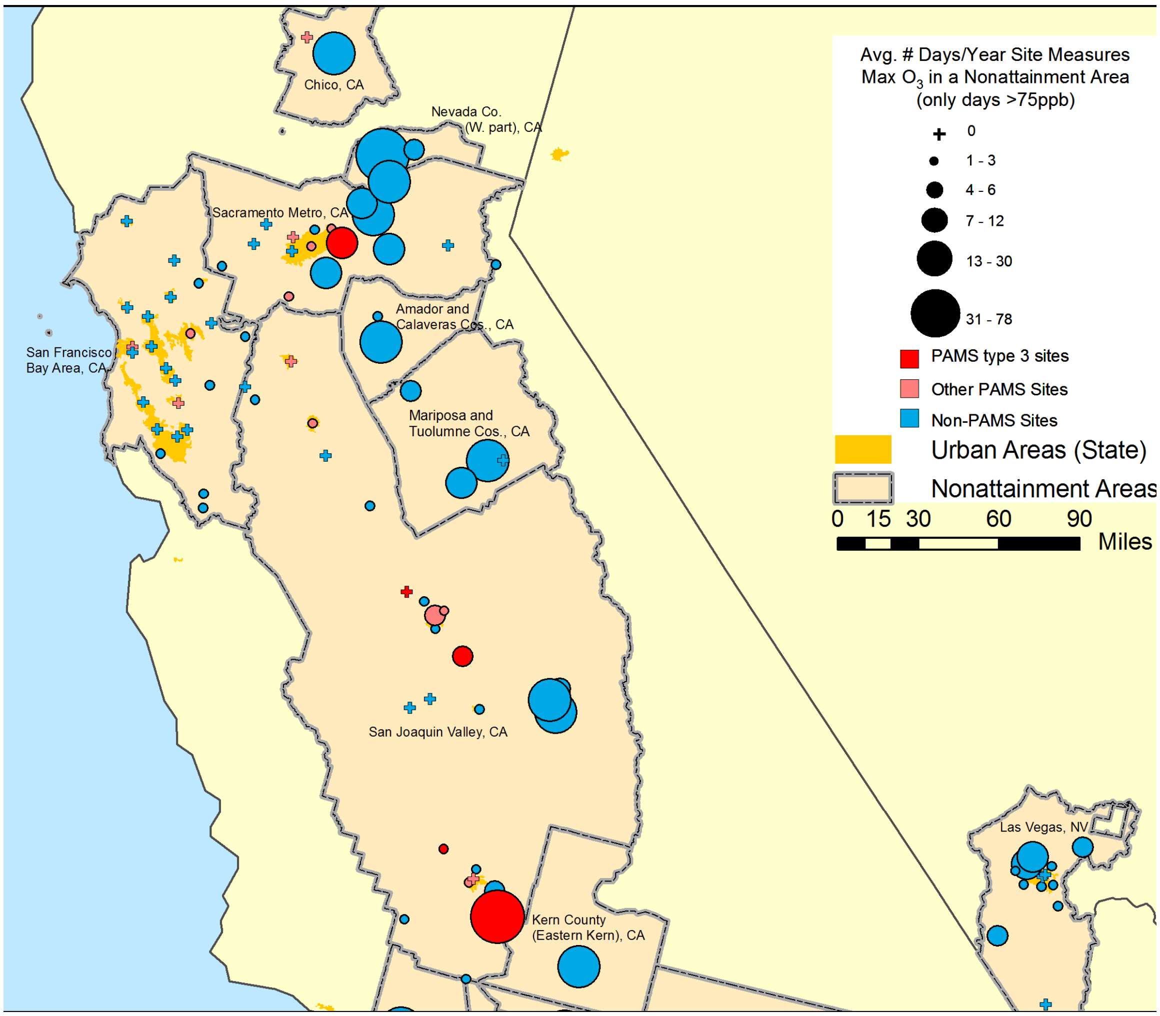

Figure 4-27. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Central California.

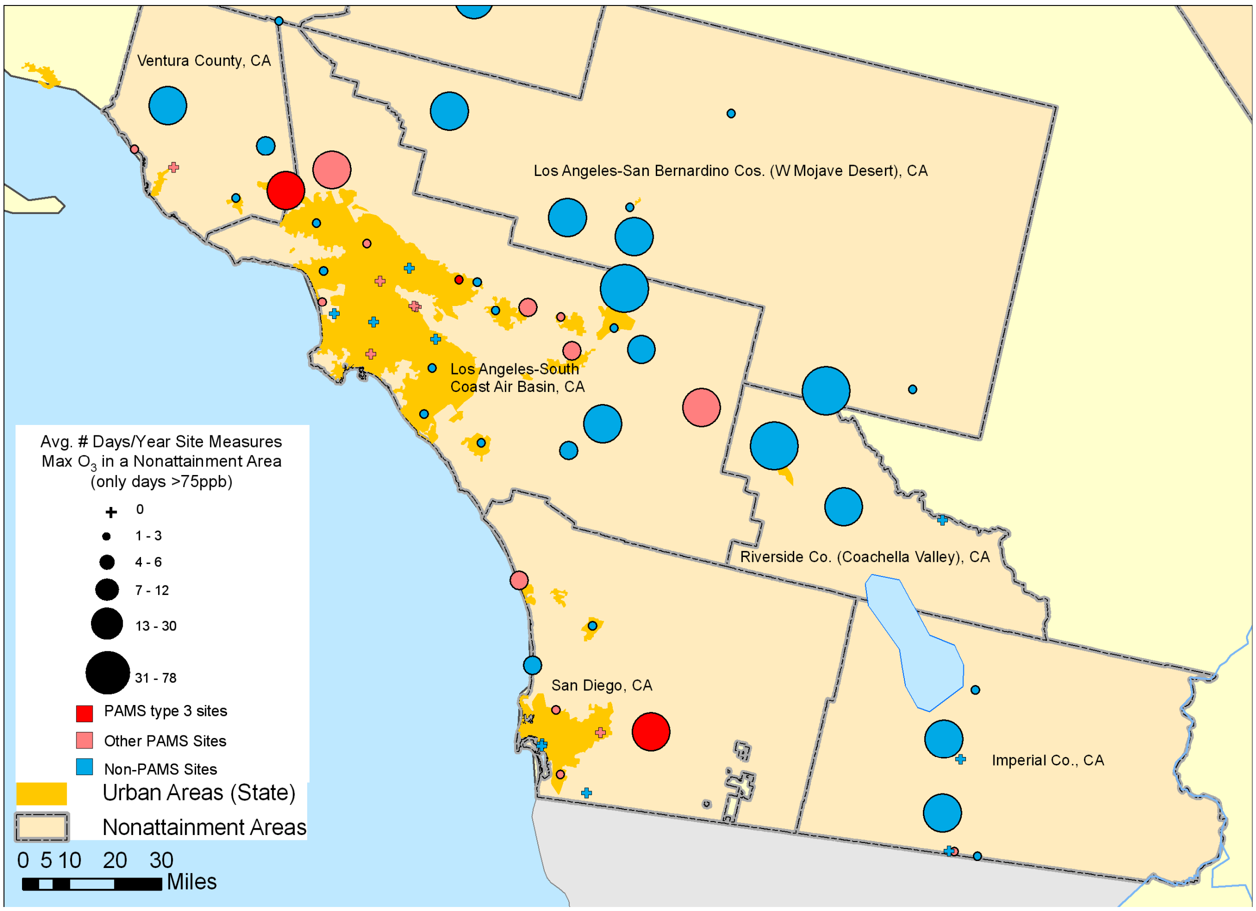

Figure 4-28. Average number of days a site reported maximum ozone concentrations greater than 75 ppb in nonattainment areas in Southern California.

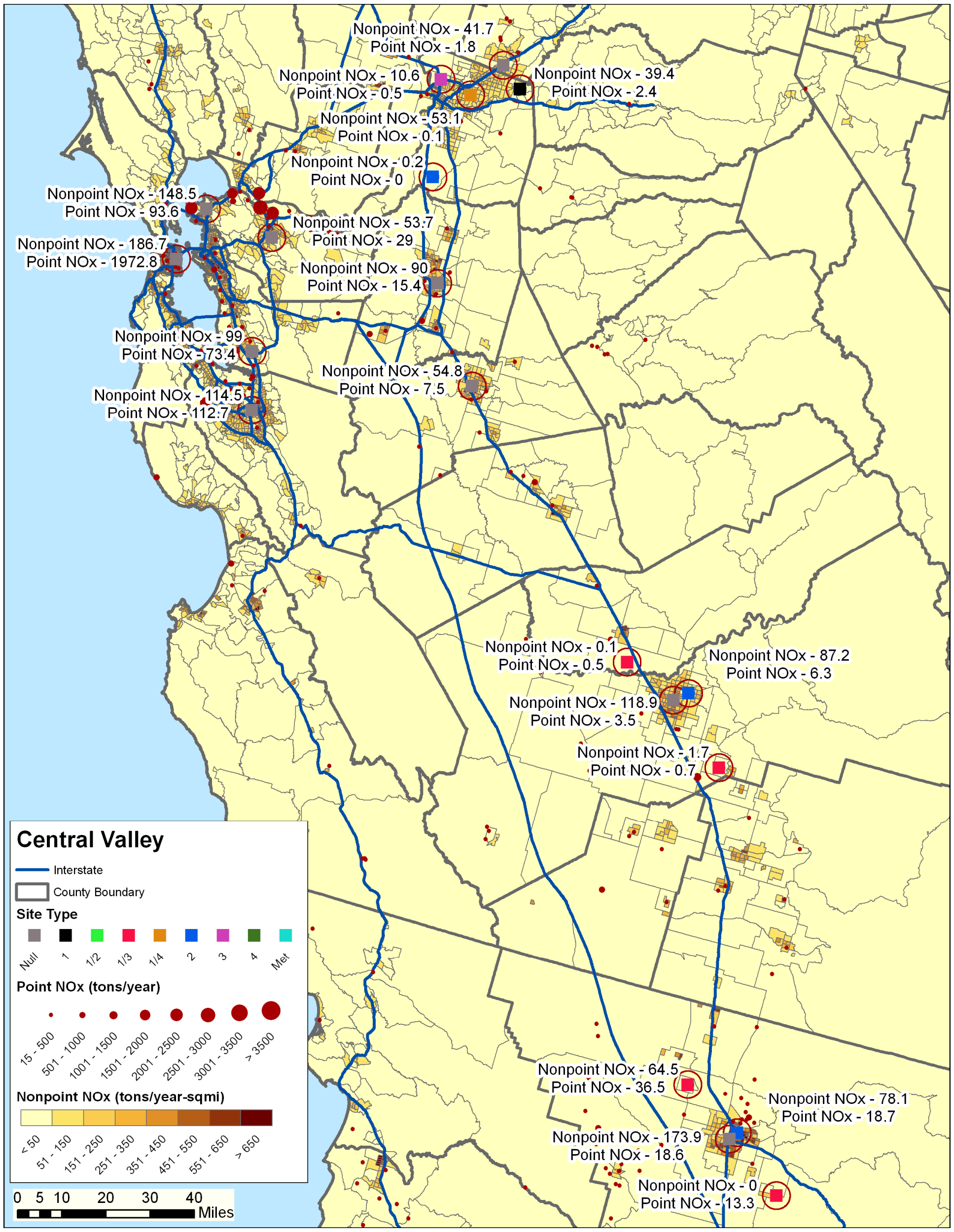

Figure 4-29. Emissions density of NO_x in Central California in 2002.

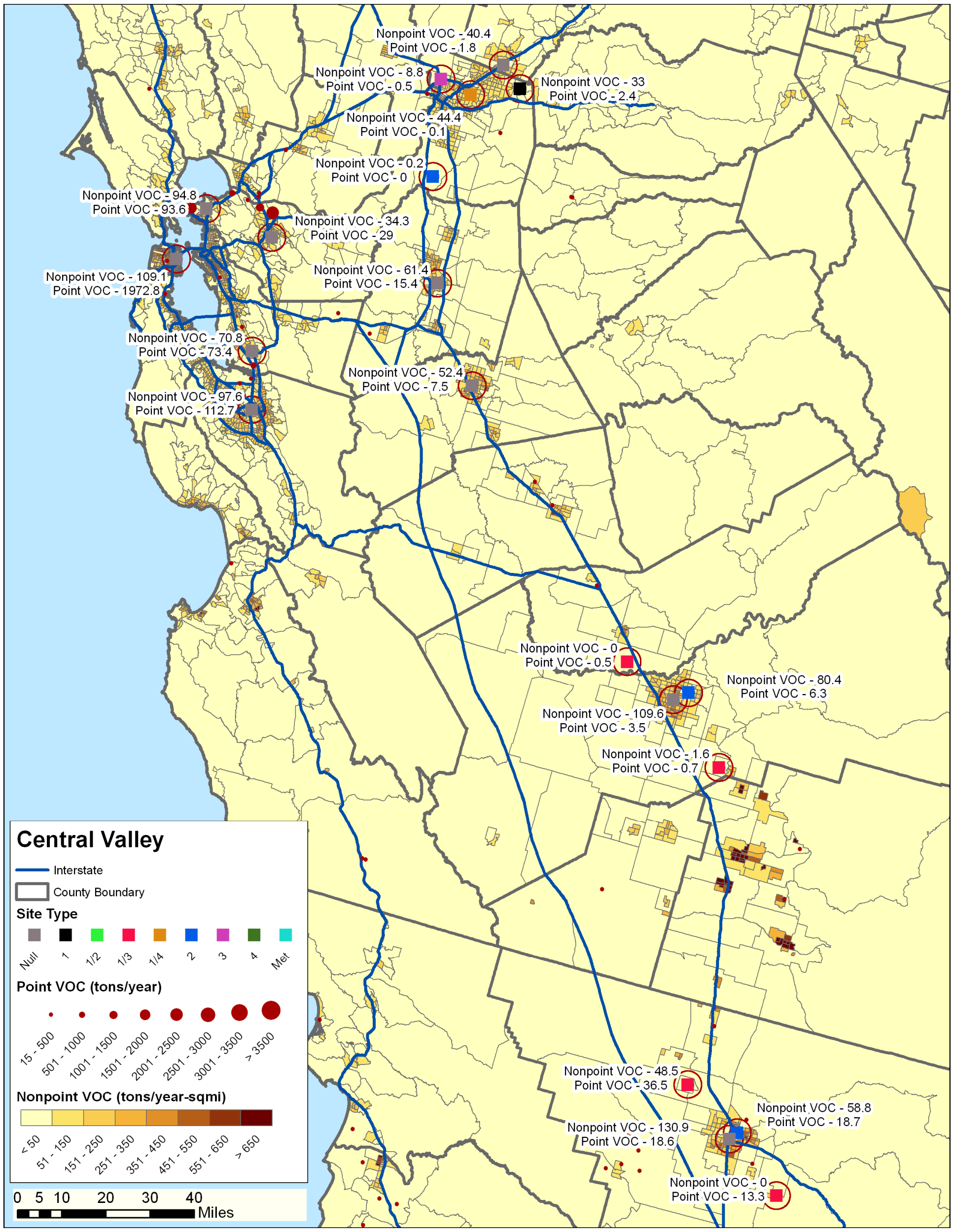

Figure 4-30. Emissions density of VOCs in Central California in 2002.

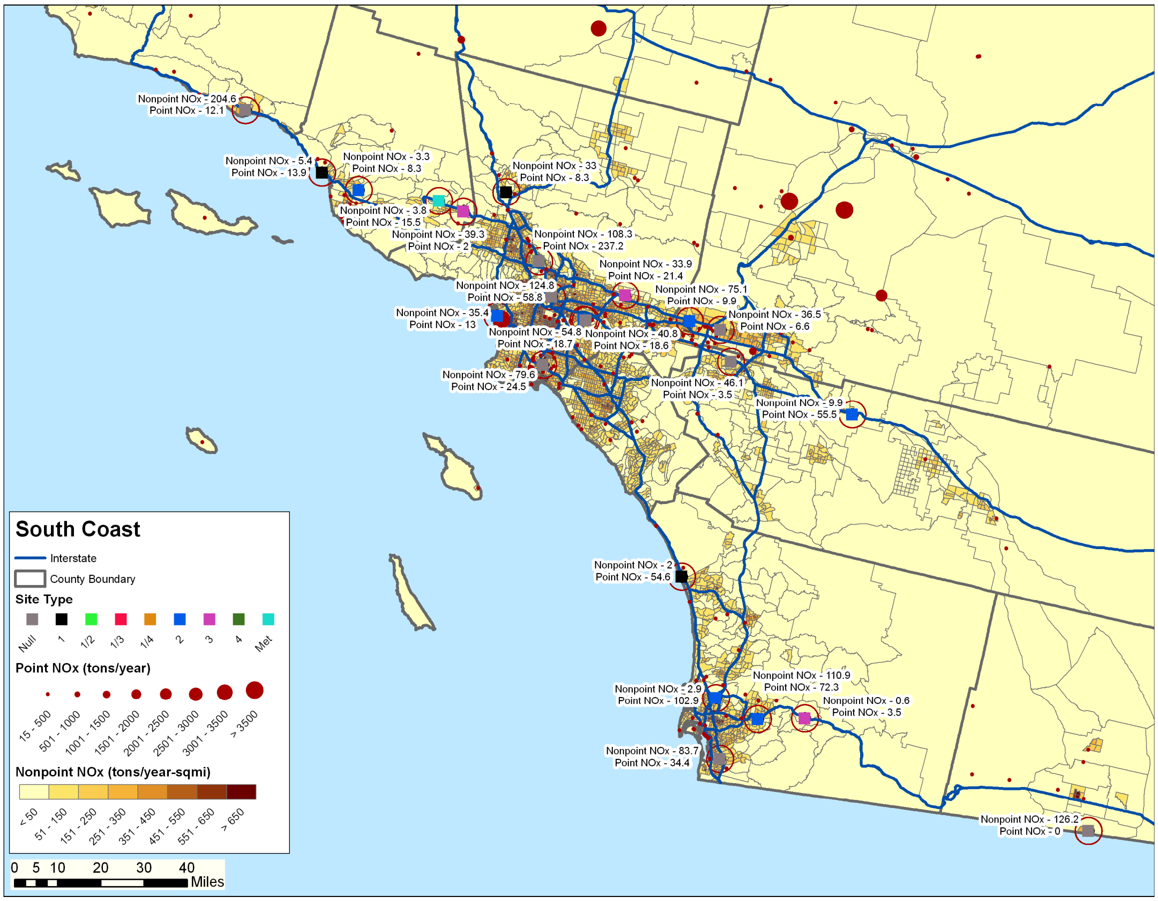

Figure 4-31. Emissions density of NO_x in Southern California in 2002.

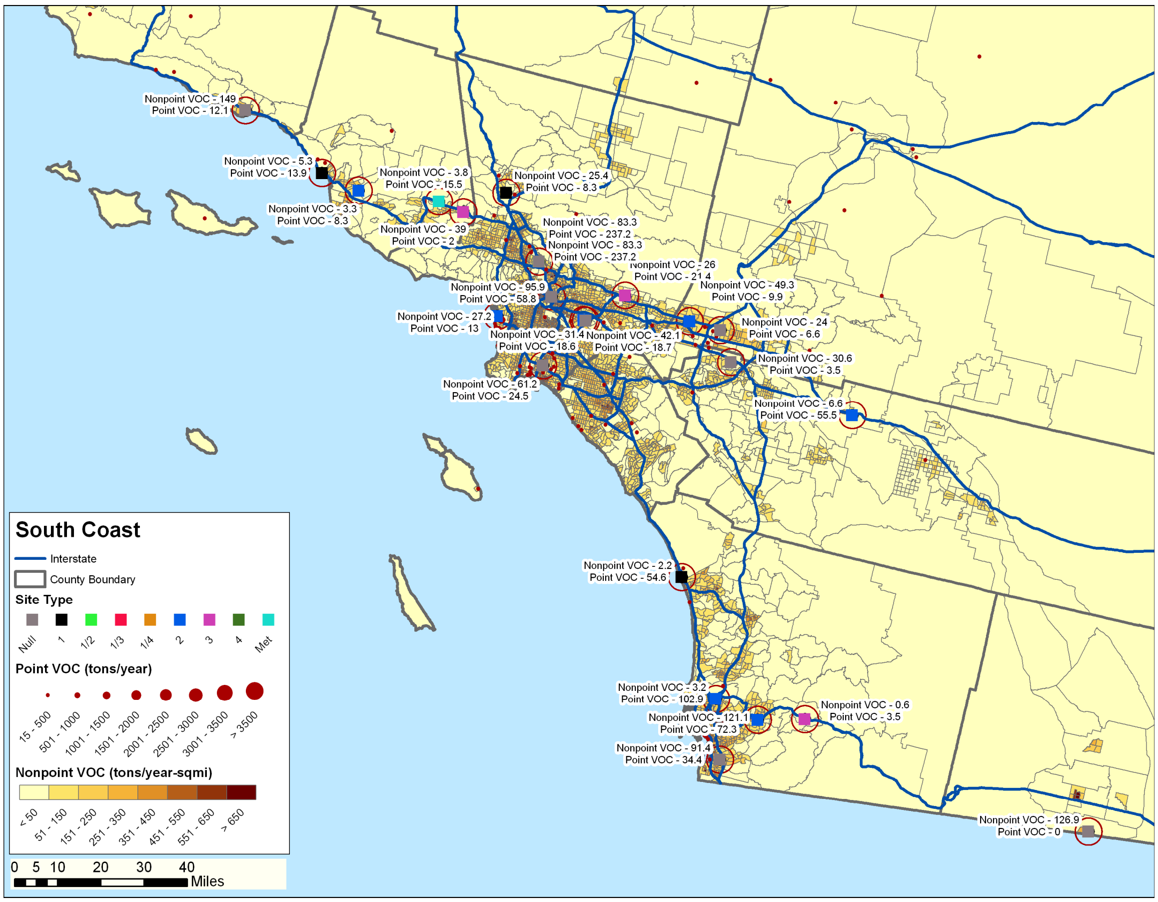

Figure 4-32. Emissions density of VOCs in Southern California in 2002.

Table 4-7. Region 9 site-specific observations.

Type	Current Site	Analysis Comments
1	CA – LAX Hastings	High absolute concentrations, low relative to other sites; characteristic of a Type 1 site under typical wind conditions.
	CA – Camp Pendleton	Low concentrations; consistent with Type 1 site characteristics.
	CA – Elk Grove	No hydrocarbon speciation, low VOC and NO_x concentrations; consistent with Type 1 site characteristics.
1/2	CA – Burbank	Highest concentrations in the country; reclassify as a Type 2 site.
2	CA – Bakersfield	Highest local concentrations; consistent with Type 2 site characteristics; improve data quality.
	CA – Pico Rivera	Very high NO_x concentrations; consistent with Type 2 site characteristics.
	CA – Santa Clarita	High ozone, VOC, and NO_x concentrations; consistent with Type 2 site characteristics.
	CA – El Cajon	Highest local concentrations; consistent with Type 2 site characteristics.
	CA – Overland	Slightly lower VOC concentrations than El Cajon; consistent with Type 2 site; evaluate the usefulness of site.
	CA – Clovis Villa	High VOC, somewhat low NO_x concentrations, low predicted emissions; evaluate if site best meets Type 2 characteristics.
	CA – El Rio	Low NO_x concentrations relative to SoCAB sites; evaluate the usefulness of site.
	CA – Del Paso	Low VOC and NO_x concentrations relative to other CA sites—this site may not be capturing the highest emissions in the area; evaluate if site best meets Type 2 characteristics.
	CA – Banning	Lowest concentrations in the SoCAB among Type 2 sites; data more consistent with Type 3 or 4 site when entire LA basin is considered; consider reclassifying site.
	AZ – Supersite	No reported measurements for hydrocarbons 2004-2006.
1/3	CA – Shafter	Improve data quality; likely consistent with Type 1/3 site.
	CA – Madera	Improve data quality; consider reclassifying site to Type 1.
	CA – Arvin	Improve data quality; high ozone, consider reclassifying site to Type 3.
	CA – Parlier	Improve data quality; likely consistent with Type 1/3 site.
3	CA – Azusa	High VOC and NO_x concentrations, low ozone concentrations; site now more closely resembles a Type 2 site; consider reclassification to Type 2 site and evaluate its usefulness.
	CA – Alpine	High ozone concentrations; consistent with Type 3 site characteristics.
	CA – Simi Valley	High ozone and high VOC concentrations; likely consistent with Type 3 site characteristics.
	CA – New Folsom	Not capturing peak ozone concentrations; consider relocating site to maximum ozone area.
1/4	CA – Upland	No longer consistent with Type 4 site characteristics; consider reclassifying as Type 3.

4.7.3 Summary of Region 9 Stakeholder Discussion

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4.7.4 Regional Recommendations

- Region 9 reported the highest ozone concentrations in the country and does not appear to have a monitoring network appropriate for the current 8-hr ozone standard. Additional, regionally focused analyses are needed to understand where to best locate monitoring resources.
- Region 9 has many sites that may not be appropriately located to meet monitoring objectives.
  - Upwind and downwind sites often report concentrations that are approximately the same as those at maximum precursor sites, while the maximum ozone concentrations are no longer being captured by the PAMS networks in the SoCAB or Sacramento. A sophisticated emission inventory analysis using up-to-date data for these areas may be appropriate to determine how to rectify these problems.
  - Moving Type 3 sites further downwind may be necessary to update the network to match modern ozone concentration patterns.
  - California Alternate Plan sites do not measure total nonmethane organic compounds (TNMOC) and only measure NO_x concentrations, leaving substantial holes in the Central Valley monitoring network and at downwind sites in the SoCAB.
  - It may be useful to repurpose some SoCAB sites to monitor farther inland where ozone concentrations are highest. Current maximum ozone precursor sites are too close to the coast to capture peak ozone.
- Data quality may be improved across the region, but it is an especially large problem in the SJV. Lower MDLs are achievable and may make the monitoring data more useful for analysis efforts.
- Additional or repurposed monitors in the Sierra Foothills may be appropriate to capture peak ozone in the SJV and Sacramento areas.

5. SUMMARY OF RECOMMENDATIONS

This section provides a summary and a discussion of the national and regional conclusions and recommendations from this network assessment study. Detailed discussions of the national and regional recommendations are included in Sections 3 and 4. In this section, we focus on the key conclusions and recommendations; specific sections are referenced.

5.1 NATIONAL RECOMMENDATIONS

- *Monitoring efforts and resources should be greatest in areas where ozone concentrations are highest, and lowest in areas where ozone concentrations are relatively low.*

Due to demographic shifts, emissions changes, effective control strategies, and recent alterations to the ozone standard, the original list of PAMS areas created in the early 1990s no longer reflects ambient ozone problem areas. Therefore, EPA should consider requiring PAMS measurements in areas that are redesignated as serious ozone nonattainment areas based on the current 8-hr ozone standard of 75 ppb. The recommendations provided by Region 5 (Section 4.5.3) offer excellent options for implementing this change.

The most serious nonattainment areas are all in California. Current PAMS monitoring in the Sacramento and SJV areas appears inadequate. Monitoring resources in Southern California appear to be adequate; however, based on the results of this assessment, some of the monitors in Southern California should be moved farther downwind into Riverside and San Bernardino to better capture maximum ozone concentrations. The lack of PAMS monitoring in California is at least partially due to the repurposing of California Alternative Plan (CAP) sites as air toxics sites.

The second most serious nonattainment areas are in Texas. The number of monitors in Houston and Dallas appear to be adequate, although some of the monitors may need to be relocated to better capture maximum ozone concentrations. Isolated monitoring networks in Phoenix, Atlanta, El Paso, Baton Rouge, and Lake Michigan are close to the minimal possible size to characterize local ozone concentrations.

From the mid-Atlantic to the Northeast, the monitoring networks contain a disproportionate number and density of monitors given the magnitude of the ozone problems in these areas. In particular, the low ozone and ozone precursor concentrations in the New England area do not appear to justify the large number of existing monitors. However, this region is densely populated and may therefore warrant a denser monitoring network to address population exposure. Redundancy analyses should be performed for the sites in these areas to determine if any monitors could be removed without losing valuable information.

Note that only PAMS areas were assessed in this work. However, it was noted that some areas not designated as PAMS areas have higher ozone concentrations or larger numbers of exceedances than some areas that are currently designated as PAMS. A reassessment of the serious ozone areas under the new ozone standard would be a useful national analysis.

- *To improve data quality in key PAMS areas, EPA should consider lowering the required or minimally allowable MDL and developing a quality assurance program.*

Data quality is a region-specific issue that, when left unaddressed, can reduce the value of PAMS measurements. While all areas may be meeting minimum requirements for VOC measurements and reporting, these minima are inadequate and result in a large amount of data reported below the MDL. National-scale requirements for MDL values should be strengthened to reflect the lower precursor concentrations routinely observed. Current required MDLs are high for California and Texas and should be lowered substantially to reflect observed concentrations. In addition, the PAMS stakeholder community identified the need for a program-level quality assurance program similar to that adopted for the current air toxics program.

- *Most maximum ozone concentration monitoring sites should be reassessed and relocated.*

Analyses showed that many Type 3 maximum ozone concentration monitoring sites are not located at or near the areas of highest ozone concentrations in nonattainment areas. During the 10-15 years during which the PAMS program has been in existence, shifts in population, urban development, emissions, VOC reactivity, and the ozone standard have all changed. While maximum precursor emission sites are still generally located in areas of high emissions, multiple analyses indicated that maximum ozone concentration sites are often located too close to the urban core. Most nonattainment areas are not capturing the hydrocarbon mix at the current maximum ozone concentration areas. Given the design of the monitoring network, current Type 3 sites can be repurposed as Type 2 sites or should be relocated to capture the maximum ozone concentrations. Regional analyses should build on the analyses and recommendations from this study to identify whether local sites are properly sited to meet their monitoring objectives. Guidance on expanded network assessment analyses can be found in the EPA's network assessment guidance document (Raffuse et al., 2007).

- *EPA should consider improving accountability for the PAMS program dollars, including regularly reporting data quality and use. In addition, updating the EPA website with local and regional PAMS reports would be useful for information sharing.*

Currently, there is no official program for organizing the products associated with the PAMS program. Most of the information available on the website (U.S. Environmental Protection Agency, 2008a) is out-of-date. No internal QA programs are run by EPA to assess the quality of data being produced by PAMS monitors. EPA should consider providing additional support and organization for the data being collected under the PAMS program.

5.2 REGIONAL RECOMMENDATIONS

- *Each region should perform a regional network analysis to determine if their current networks are sufficient to meet monitoring objectives.*

The analyses performed in this national network assessment were necessarily broad and simple in scope. As a result, these analyses could not incorporate as much local user information as a smaller regional analysis might. Given the smaller size and scope of a regional network assessment, more sophisticated analyses examining local networks would be targeted to local needs and questions. These analyses should identify unique regional issues and examine how to allocate national funds to effectively meet the PAMS monitoring objectives.

- *Redundancy analyses of existing sites should be performed.*

All regions with dense monitoring networks have sites where ozone and ozone precursor concentrations are very similar as illustrated in the maps created for this network assessment. This similarity indicates that ozone season concentrations are relatively homogeneous across a wide range of common ozone precursors. Given this homogeneity, some of the existing monitoring sites may be redundant. However, the analyses performed as part of this study did not address the short-term temporal patterns in concentrations within EPA regions, nonattainment areas, or regional monitoring networks. We recommend performing analyses to examine the redundancy of monitoring sites. Redundancy analyses could include source apportionment, correlation analyses, or simple scatter plot matrices. Redundancy analyses are most important for sites that are currently designated as maximum precursor emission sites.

6. REFERENCES

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